POWER

Volume 55 New York, June 27, 1922 *Number* 26

Filing Information

IN RESPONSE to the letters that I have recently sent out asking how *Power* could be made to better meet the needs of its users, have come several wishes that we could print it in some way so that any particular article could be cut out for filing without mutilating another article.

The only way that we know to do this is to back every reading page up with an advertisement. We have thought, and still think, that *Power* readers prefer a paper in which the reading matter and the advertising are kept separate.

There is, moreover, so much neater and more flexible and convenient a way to file or index such material, that any distortion of the natural arrangement of magazines seems to be uncalled for.

In any stationery store buy some standard 3 x 5 index cards. They come in different colors and with different rulings. Mine are white with a red line 7/16 of an inch from the top and blue ruling spaced one-quarter inch over the rest of the surface.

If you see an article, say on condensers, that you think you may want to refer to, write "Condensers" in the upper left-hand corner of this card, above the red line. Then below the red line, on the blue ruling put the title of the article and the author's name, the name and date of the paper in which and the number of the page upon which it appears. You can also write a brief characterization of the article, saying whether it deals with condenser design, is a theoretical analysis of heat transmission, gives results of tests or experiences or practical directions for cleaning or some other maintenance phase. By using the back of the card you can copy formulas, data or brief observations.

Buy also a set of cards having projections or tabs on their upper edges each bearing a letter of the alphabet. Take an envelope box, a cigar box or, better still, make a box into which these cards will nicely fit, and as your cards accumulate, put them into the file each in front of the proper alphabetical card (the condenser card in front of C, etc.). This file will bring together in one group of cards references to all that you encounter and think worth recording in your reading, your practice, your talk with others, your attendance at lectures, etc., about condensers; in another group, under T, all that you find about turbines, etc., and it can refer to books and catalogs and all sorts of sources and repositories. It need not fill up with dead material like a scrapbook, for as the material upon the cards becomes obsolete or is found not to have the expected interest, it can be discarded without affecting the continuity or integrity of the system.

For filing clippings, pamphlets, catalogs, etc., use the 9 x 12 heavy paper jacket, having a tab or projection on the top or open edge. Put your loose material into these, number them consecutively and refer to them from the card index by number. Certain numbers and groups of numbers will naturally be devoted to certain subjects, and information pertaining to these subjects brought together. When you outgrow the cigar box for your index and the soap box for your jackets, cabinets purposely made in wood or metal may be had at small cost.

Doubtless many of our readers follow some such system of filing. We should like to have experiences and suggestions.

F. R. Low

Queenston-Chippawa Hydro Development Largest in the World

Initial Installation Five 55,000-Horsepower Hydro-Electric Units—305 Feet of the 327 Foot Head Between Lake Erie and Lake Ontario Effective on Turbines —Water Carried Through Concrete-Lined Canal Designed for Possible Ultimate Capacity of 600,000 Horsepower

LAKE ERIE is situated at an elevation 327 ft. above Lake Ontario, and the two lakes are connected by the Niagara River, which has a normal flow estimated at 210,000 cu.ft.-sec. This flow, if utilized under the full head of 327 ft. in modern turbines, is capable of producing 7,000,000 horsepower-years. To develop this power in the most modern steam plant would require the burning of about 35,000,000 tons of high-grade coal, or if the higher coal consumption per horsepower-hour of the average central station is assumed, this figure will be doubled. No wonder, then, that for many years Niagara's power possibilities have attracted the attention of the world's most capable and daring engineers. The utilization of 315 ft. of the total 327 in the Queenston-Chippawa development of the Hydro-Electric Power Commission of Ontario, the largest single hydro-electric undertaking in the world, has been the accomplishment of our Canadian neighbors.

The general scheme of the development comprises an intake structure in the Niagara River at Chippawa, widening and deepening the Welland River for about 4½ miles between Chippawa and Montrose, the construction of a canal 8½ miles long between Montrose and the forebay near Queenston, and a plant on the bank of the Niagara River. This location utilizes all but 12 ft. of the total head between the two lakes, 9 ft. from Lake Erie to Chippawa and 3 ft. from Queenston to Lake Ontario. It probably will never pay to attempt to use the former, and the latter is impossible to utilize. This leaves 315 ft. fall between Chippawa and the plant location near Queenston. When the plant is in full operation, about 10 ft. of this will be lost in the canal system and penstocks, leaving 305 ft. average net head on the turbines.

There is no coal in the Province of Ontario, the only available supplies of Canadian coal being in the extreme eastern and western sections of the country at distances rendering its transportation commercially impossible. Consequently, the importance of water power to the Province and its most economical development are readily appreciated. However, Ontario is fortunate in having abundant water-power resources, aggregating approximately 6,000,000 hp., of which about 1,000,000 has been developed.

Although handicapped by having no coal but that imported from the United States, there has grown up in the region surrounded by Lake Huron, Georgian Bay, Lake Erie and Lake Ontario the great manufacturing district of Canada. The industrial development was first taken care of in this district by many small water powers. With the growth of this district these water powers became unreliable and inadequate and steam plants were necessary for the factories. This caused many of those interested in industrial development to turn their attention toward a supply of cheap power from Niagara Falls and as a result of a movement

started in 1900, the Hydro-Electric Power Commission of Ontario was appointed in 1907 by the Provincial Government, with Sir Adam Beck as its chairman.

The Commission, as it now functions, generates power in hydro-electric plants and sells it wholesale to the municipalities at cost. Since 1910, when the Commission first started to transmit power from Niagara Falls over a single system supplying 750 hp. to 10 municipalities, its activities have increased until in 1921 it operated 11 distinct systems embracing practically the whole province, supplying 305,000 hp. to 260 municipalities and townships and many large industries as well as exporting 70,000 hp. to the American side.

The power developments at Niagara Falls are so large that they are like the Falls itself in that they must be seen to be appreciated. When developments that are under way and scheduled to be in operation by the end of 1923 are completed, there will be installed a total capacity of 1,389,000 hp. Of this, 1,054,000 hp. is in plants at the Falls, 275,000 hp. in the Queenston plant, and 60,000 hp. at De Cew Falls, near St. Catharines. The last-named plant takes water from storage lakes at the summit level of the Welland Canal at the top of the Niagara escarpment and uses it in a plant on the bank of what is known as the 12-Mile Creek, obtaining a head of 250 ft. The location of this plant is indicated in Fig. 2. All the plants at the Falls and their capacities are indicated in Fig. 1. When the present construction is completed, some of the older and less efficient plants will be used for stand-by service only, and the water now going to these plants used in more efficient developments where 100 per cent more power can be produced from the same quantity of water.

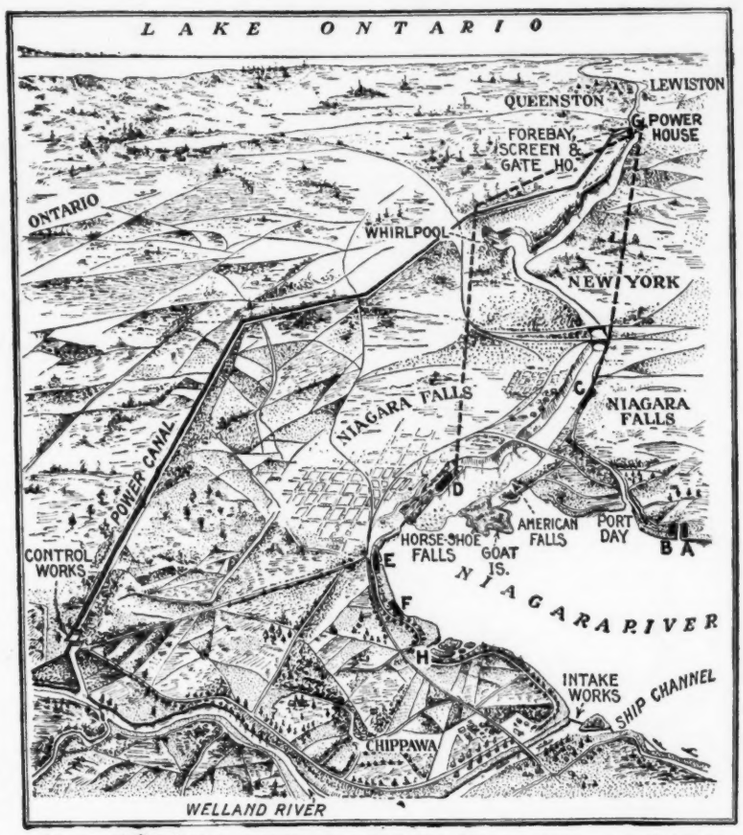


FIG. 1. BIRD'S-EYE VIEW OF NIAGARA FALLS AND QUEENSTON-CHIPPAWA DEVELOPMENT

On the American side of the Falls plants are indicated at three locations: *A*—Niagara Falls Power Company's Plant No. 2 (61,500 hp.); *B*—Niagara Falls Power Company's Plant No. 1 (55,000 hp.); *C*—Niagara Falls Power Company's Hydraulic Plant No. 2 (26,500 hp.), Hydraulic Plant No. 3 (130,000 hp.), and Extension No. 3 (112,500 hp.). Another extension to No. 3 of 210,000 hp. is now under construction. On the Canadian side are four plants: *D*—Ontario Power Company's plant (200,000 hp.) owned by the Hydro-Electric Power Commission of Ontario; *E*—Canadian Niagara Falls Power Company's plant (112,500 hp.); *F*—Toronto Power Company's plant (146,000 hp.); *G*—Queenston Plant of the Hydro-Electric Power Commission, 275,000 hp. to be installed by end of 1922. This development is laid out for an ultimate capacity of 600,000 horsepower.

Although by far the largest portion of the water is on the Canadian side of the river, the most favorable topographical conditions for power development are on the American side. Fig. 1 shows that there is an abrupt curve in the river with Niagara Falls, N. Y., on the inner side of the curve. This makes the distance that water must be carried either by tunnel or open canal, to obtain a given head, much shorter on the American side than on the Canadian. Where it is possible to dig an open canal from Port Day to below the Falls at *C* and obtain a head of 215 ft. as now used, a pressure conduit from *H* to *D* gives an effective net head of only 170 ft., which is the highest head utilized at the Falls on the Canadian side. Furthermore, on the New York side conditions are favorable for a two-step development as now proposed. A tunnel may be driven from the present plants located at *C*, in almost a straight line in solid rock to near Lewiston, as indicated by the dotted line, and the tailwater from the present plants taken through this tunnel and used under a 90-ft. head. On the Ontario side, if such a development were attempted, the tunnel would have to follow a course from *D* at the Falls to somewhere near Queenston, similar to that shown by the dotted line. In this route the tunnel would have to cross the gorge at the Whirlpool, the bottom of which is composed of clay and quicksand, making such development a difficult and hazardous engineering undertaking. It has long been realized by engineers interested in seeing Niagara's power developed in the most efficient manner that some other method of development must be employed than that at the Falls on the Ontario side, which only obtains in the most efficient plant about 50 per cent of the total potential energy in the water flowing from Lake Erie to Lake Ontario. One of the various plans originally proposed, which was also considered the most practical of the several suggested, was to dig an open canal from Morgan's Point on Lake Erie across the Niagara peninsula to the brink of the escarpment above Jordan Harbor on Lake Ontario. From here the water was to be carried in a pipe line one mile long to the power house. This route is indicated on the left in Fig. 2. However, it remained for the shortage of power that developed early in the war, to provide the stimulus for concrete action in this direction. Realizing that the limit of power development at the Falls was fast approaching the present limit for water diversion (36,000 cu.ft.-sec.), the engineers of the Hydro-Electric Power Commission of Ontario, who had been studying this problem for a number of years, took definite steps toward utilizing the remaining water

under the most economical maximum head between the two lakes. Several schemes were considered, among them the Jordan-Erie project already mentioned. This one was discarded on account of the unfavorable intake conditions at Lake Erie, structural difficulties and unavoidable head losses in connection with the 24-mile canal and the regulation difficulties attendant upon the control of a column of water one mile long in a penstock between the forebay and the power house. The most economic effective head when capital costs were balanced against head, worked out slightly less than 300 ft. for this scheme, with the greatest portion of the losses being caused in the long canal.

In studying the map, Fig. 2, another method that is suggested is the use of the Welland Canal. This is open not only to the same objections as the Jordan-Erie project, but also to the possibilities of interfering with navigation.

As the problem worked out, by far the best intake conditions were found at the mouth of the Welland River at Chippawa, about 2½ miles above the Falls. A suitable site for a power house was obtained in the Gorge about one mile above Queenston, that required penstocks only about 450 ft. long, and this reduced the problem of regulation to one easily handled.

After the intake and power-house site had been decided upon, the next consideration was how to connect these points by a suitable waterway. An exhaustive series of surveys and core-drill borings established that either a canal or pressure-type tunnel could be constructed. However, the pressure tunnel presented a number of disadvantages, such as driving the headings at an acute angle through the various limestone, shale and sandstone formations, unfavorable conditions for disposal of excavated material, unknown water hazards, the difficulty and hazards of driving a tunnel of such unprecedented large diameter through the clay formation of the Whirlpool ravine and the difficulty that would be involved in the construction of a distributing chamber in the shale and sandstone at Queenston. None of the foregoing entered into the problem with the open canal. From an engineering viewpoint only two outstanding difficulties presented themselves, namely, the removal of the overburden in the canal prism, and the permanent holding of the slopes subsequent to such removal.

A consideration of the hydraulic characteristics of the two plans showed that the canal would deliver a given amount of water to the forebay with a materially less loss in head than the pressure tunnel for any headwater level above an assumed minimum. Furthermore, the canal will deliver a constantly increasing quantity of power in proportion as the headwater level rises above an assumed minimum. This the pressure tunnel cannot do to any appreciable extent on account of its inherent characteristics. The open canal was the only agency that would automatically make available any increased quantity of power due to an increase of headwater level. This factor is an important one, since the growing power demands of electrochemical and electrothermal industries will make possible the sales of the large quantities of seasonal and intermittent power which will thus be made available during the higher stages of flow in the Niagara River.

In 1913, when the Commission requested the Ontario government to allow it to proceed with the Queenston-Chippawa development, it was proposed to construct a power development and canal with an initial capacity of only 100,000 hp. and a maximum of about 180,000 hp. This was the idea under which the work was undertaken in May, 1917, as a means of meeting the need for additional power for war demands. By the time that the crisis of the war was past in 1918, it became necessary to reconsider the status of the project in the light of future industrial development. The rate of industrial growth in the Niagara district clearly indicated that unless a much more extensive hydro-electric development was undertaken than at that time proposed,

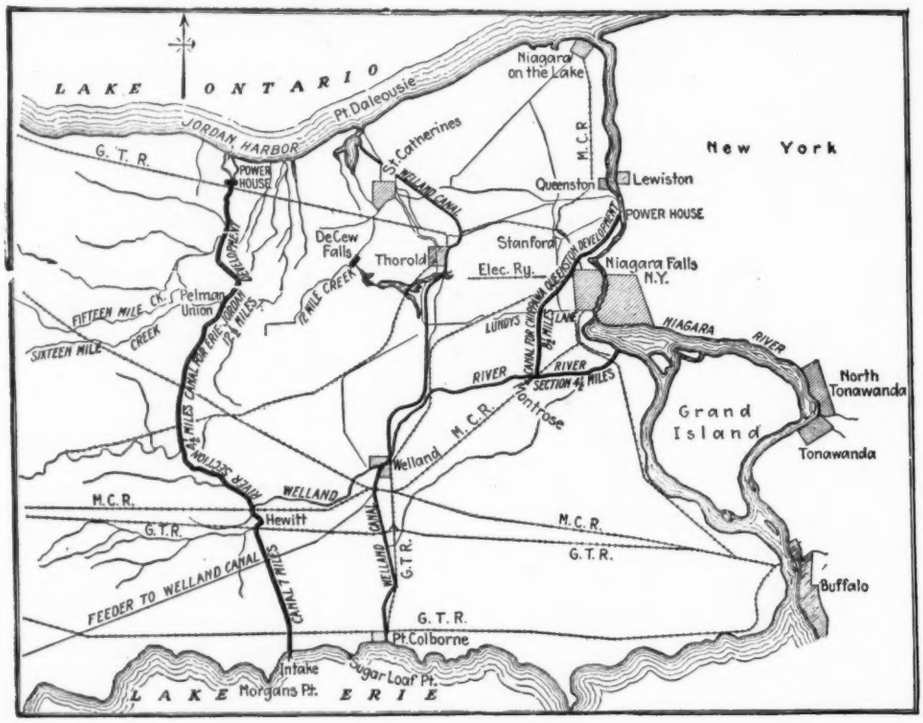
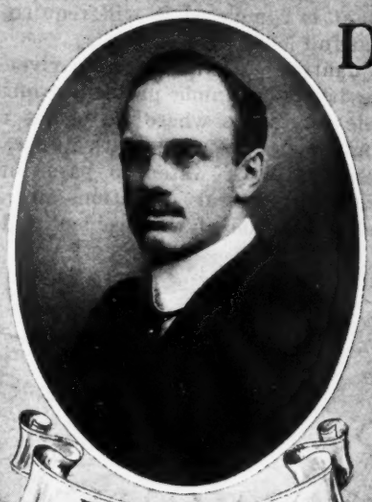


FIG. 2. MAP OF NIAGARA PENINSULA SHOWING ROUTES OF THE ERIE-JORDAN AND QUEENSTON-CHIPPAWA CANALS.

One of the most practical of the proposed schemes for developing power under the full head of 327 ft. between Lake Erie and Lake Ontario was to dig a canal 24 miles long from near Morgan's Point on Lake Erie to the top of the Niagara escarpment near Jordan Harbor on Lake Ontario. The most economical effective head when capital costs were balanced against head, worked out slightly less than 300 ft. By making the Queenston development an effective head of 305 ft. was obtained in a waterway only 13 miles in length. At Queenston the penstocks are only 450 ft. long, whereas at Jordan Harbor they would have to be about 1 mile long.

Some of the Men Responsible for the QUEENSTON - CHIPPAWA DEVELOPMENT



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ASSISTANT ELECTRICAL ENGINEER

this district in three years' time would again be as seriously handicapped by the lack of an adequate supply of power as it had been all through the war period. To provide a development that would not only meet present demands, but could be easily extended to take care of the future for some time to come, the original Queenston-Chippawa development was transformed from a war undertaking designed to meet an urgent need, to a commercial scheme embracing the elements of both true conservation and the ultimate maximum of economy in the production of power from Niagara Falls. In view of all the facts it was found best to provide for an initial development of 275,000 hp. and a complete canal installation for a possible maximum capacity of 600,000 horsepower.

Power developments at Niagara Falls, like most all others in northern localities, have their operations seriously interfered with by ice for a considerable period of the year. Ice starts to form in Lake Erie early in December, in the average winter, and soon thereafter begins to discharge through the Niagara River, and continues until about the middle of May.

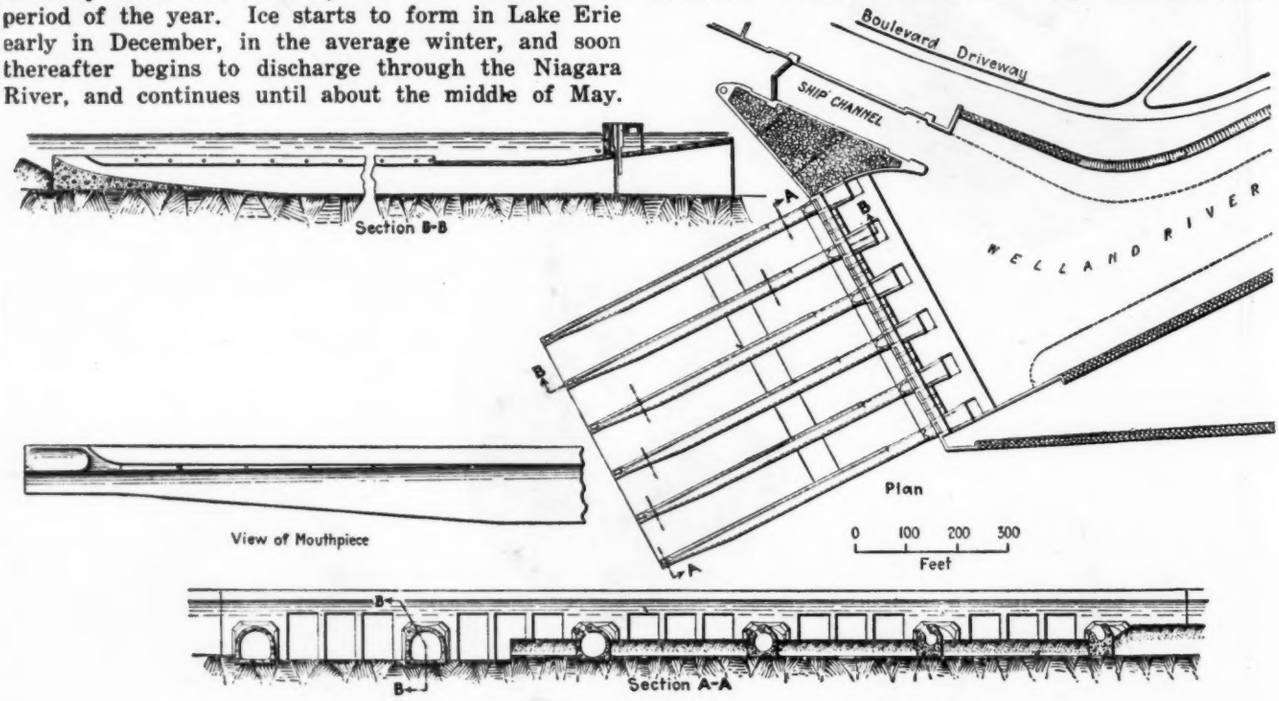


FIG. 3. PLAN AND SECTIONS OF INTAKE WORKS AT CHIPPAWA

Some ice also forms in the river, particularly along the shores, where, on account of the shallow water, it picks up stones and other débris, which, if taken into the plant, may damage the turbines. A sudden change in temperature fills the water with slush or needle ice which, when it strikes the diverters intended to keep the ice out of the plant, freezes into a solid mass and gradually blocks the openings through which the water flows. The slush ice makes it impossible to use the racks intended to keep floating rubbish out of the penstocks, and the turbines must operate without this protection during the winter months. Every winter the plants on the Canadian side of the Falls have been more or less handicapped on this account. In many instances ice has caused these plants to operate at reduced capacity, or the complete shutting down of units. This was also the case on the American side of the river until, in 1919, improved methods for preventing the ice from blocking the intake were completed.

While it is practically impossible to prevent ice troubles in the plants now built at the Falls on the Canadian side, owing to the relation of the intake works to the river and on account of conditions that cannot now be changed, it is expected that with the Queenston plant no serious troubles will arise. On account of the size of the intake for this plant and its location at Chippawa, special problems were involved, to provide intake works that would insure at all times sufficient water to operate the plant. Some idea of the proportions are realized if it is understood that when the Queenston plant is completed it will require about 18,000 cu.ft.-sec. at full load.

To take large quantities of water from a river heavily laden with ice is not a simple problem even under the most favorable conditions where ice booms can be used for skimming the surface water with its ice, while allowing the lower strata of water to pass into the intake. At Chippawa natural conditions were not favorable for such a solution of the problem and radically different methods were adopted. The necessity of this was confirmed by several years' experience and observation by the Commission's engineers with the present plants on the Canadian side of the Falls. After two years of engineering study and experimental work on large-sized models, duplicating to scale the topographical conditions existing at Chippawa, a new type of intake works, Fig. 3, was developed, which it is confidently expected will keep the intake free from ice.

This type of intake combines two forms of intakes, each complete within itself. One of these is of the ordinary type which combines a concrete dam and curtain wall, and the other consists of six cigar-shaped concrete tubes on the bottom of the river but extending through the first. These tubes are 675 ft. long and each has a slot running from its small end for 500 ft. of its length. The slot is on the upstream side and varies in width from 1 ft. at the shore end to 4 ft. at the outer end, where a restricted section, shaped similar to a bathtub, forms a mouthpiece for each tube to give the required initial impulse to the water. Section *AA*, Fig. 3, shows the shape of the slots and tubes at

different points along their length. The discharge ends of these tubes form part of the dam and curtain wall across the intake and are flared to act as a diffuser for the flow of the water into the Welland River, thus creating a minimum disturbance and loss of head.

In the intake works dam there are three gates between each pair of tubes and a gate in each tube. When there is no ice flowing in the river or the flow is light, all gates will be open and the curtain wall

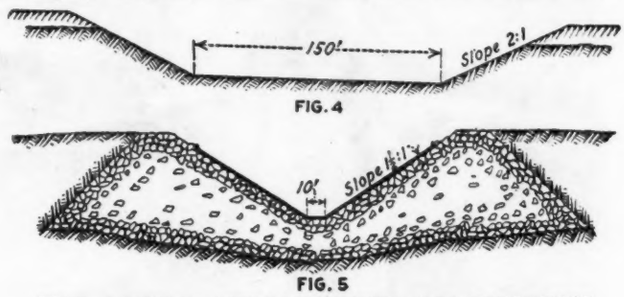


FIG. 4

FIG. 5

FIGS. 4 AND 5. WELLAND-RIVER AND WHIRLPOOL SECTIONS OF THE POWER CANAL

Fig. 4—Welland River after enlargement and portion of canal excavated entirely in earth. Fig. 5—Rock fill and power canal crossing whirpool gully.

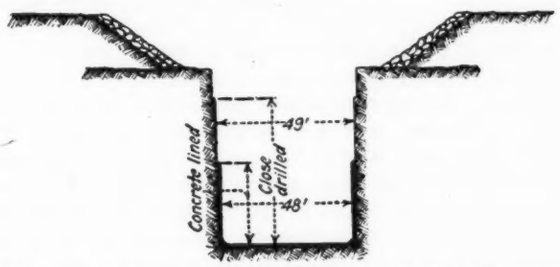


FIG. 6. CANAL AS EXCAVATED IN ROCK, SHOWING CONCRETE LINING AND EARTH SLOPE

will prevent any débris from entering the canal. Under this condition the head loss through the intake will be negligible. When the ice is heavy, the gates between the tubes will be closed and the flow into the canal will be through the submerged intake. Since the tubes will be normally about 14 ft. below the surface of the water, it is expected that the flow of the water into them will not interfere with the flow of the ice on the surface or that the ice can pile up high enough at the intake to interfere with the flow of water into the canal.

The rate of flow into the slots for 15,000 cu.ft.-sec. through the submerged intake has been taken at 2,500 cu.ft.-sec. along the axis of the tube, and with this flow the total head loss in the tubes up to the end of the diffuser will be only 0.3 foot.

These tubes may be considered as being made up of three sections: An outer tapering section wherein the velocity is maintained constant, with a longer inner section, 20-ft. inside diameter, in which the velocity regularly increases with respect to distance along its axis, and a diffuser section on the inner end, where the velocity is reduced with as little loss as possible, to that existing in the Welland River section.

It is interesting to note that in working out the engineering problems involved in the design of these intake tubes, and for the flow of the water in the canal, new mathematical methods of analysis were developed by R. D. Johnson, consulting engineer, New York City.

The total length of the canal from the intake to the forebay is 13 miles. For 4½ miles from the intake at Chippawa on the Niagara River to Montrose, the Welland River has been deepened and widened to have the shape indicated in Fig. 4 with a normal depth of 35 ft. The canal proper starts on the Welland River at Montrose and for about one mile is an earth-cut of the same shape as the river. This section, as originally designed, was to be concrete lined, but a careful study of the economic, constructional and operating conditions indicated that the advantages of the larger section would compensate for the cost of the extra excavation.

At the end of the earth section there is a transition section 300 ft. long in which the canal changes to a concrete-lined rock cut, 36,252 ft. long, 48 ft. wide, with vertical sides as indicated in Fig. 6. The height of the concrete lining varies from 33.5 ft. at the entrance to 30 ft. at the forebay. For a distance of 2,450 ft. in the Whirlpool section, which is a rock fill, the canal takes the shape indicated in Fig. 5. For a greater part of the time the water will be above the concrete lining, since a depth of from 40 to 35 ft. of water is provided for.

The Whirlpool section crosses an old gorge the bottom of which is composed of clay and quicksand. The construction of the canal across the valley was accomplished by first filling the whole gorge with rock excavated from other parts of the canal, and then allowing the fill to come to a final settlement after which it was excavated for the canal section and faced with a heavy reinforced-concrete lining.

In the canal, which is the largest concrete-lined one in the world, the maximum depth of cutting is 72 ft.

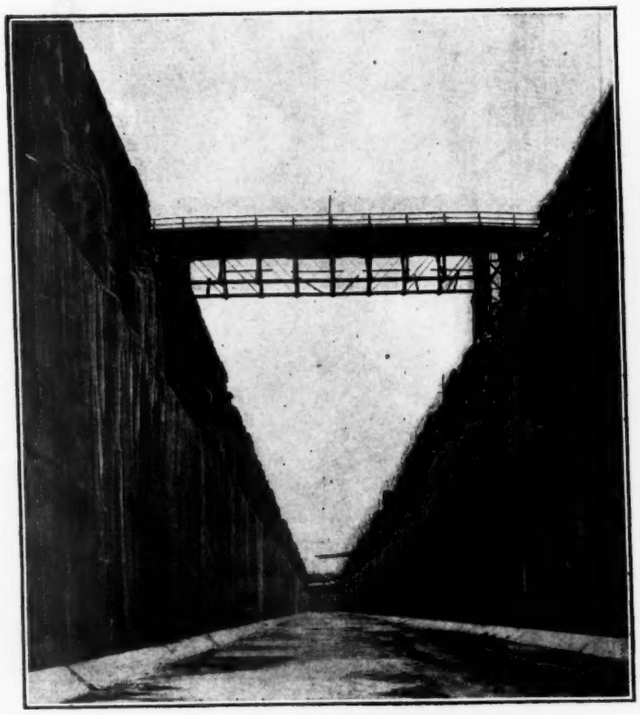


FIG. 7. VIEW OF CANAL WHICH IS LARGEST CONCRETE-LINE POWER WATERWAY IN THE WORLD

in earth and 85 ft. in rock. At one point the bottom of the canal is 145 ft. below the original ground level. In the excavation of the canal proper over 15,000,000 cu.yd. of material was removed, over 11,000,000 of which was earth and 4,000,000 cu.yd. rock, and concrete to the amount of 303,000 cu.yd. has been used in its construction. Preliminary work was started in May, 1917, but active excavation with the large steam

shovels was not started until April, 1918, and the canal was completed in December, 1921. At one time 8,100 men were working on the project. The total volumes of earth, rock and concrete involved in the entire project are 14,500,000, 4,800,000 and 520,000 cu.yd. respectively.

At the entrance to the rock-cut section of the canal is installed a vertical-lift roller gate to control or completely shut off the water flow. This gate has a clear width of 48 ft. by 42½ ft. high, which makes it the largest in the world. Fig. 8 shows the gate in the open position, which lifts to a point 14 ft. above the water level. The gate weighs approximately 100 tons, is counterweighted and equipped for motor operation.

The canal terminates in a forebay of triangular shape, 1,000 ft. long and widens from the standard canal section to 500 ft. at the gatehouse, located at the top of the cliff just above the power house, as indicated in the headpiece, which shows an airplane view of the plant taken during construction. To prevent eddies and to smooth out any turbulence of the water entering the forebay and at the same time regain the kinetic energy in the water at the end of the canal, a triangular concrete structure has been placed where the canal enlarges into the forebay, Fig. 9. The dimensions and shape of the diffuser were determined by extensive engineering studies and test on models.

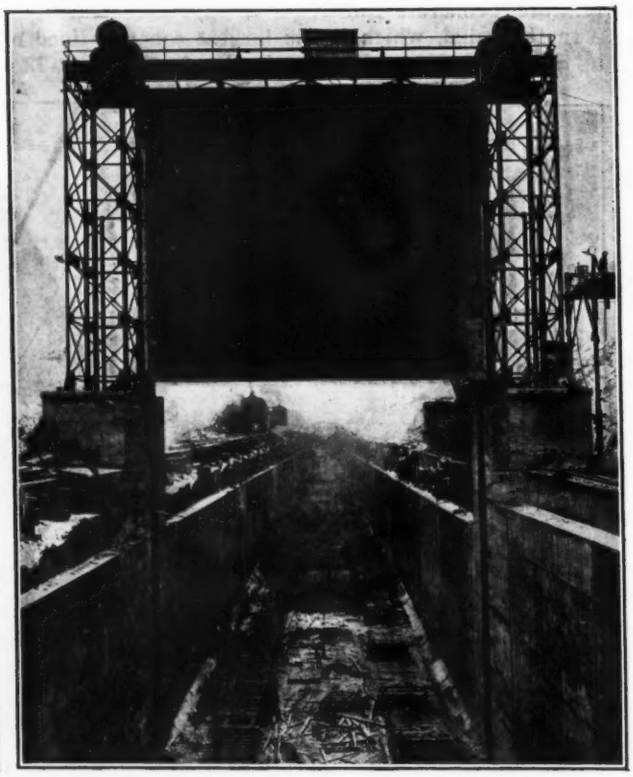


FIG. 8. CANAL GATE 48 FT. WIDE BY 42½ FT. HIGH

This diffuser forms two diverging passages for the water from the canal, each diverging at an angle of 10 deg. The diffuser is 221 ft. long, 37 ft. wide at its downstream end, stands 28 ft. high and will be submerged at all times so as not to interfere with the flow of the surface ice. By means of the diffuser the high velocity at the end of the canal is gradually reduced and its kinetic energy recovered to the extent that the water level in the forebay beyond the deflector will be about one foot higher than at the end of the canal for a flow of 15,000 cu.ft.-sec. One foot gain in head may appear to be a small item, but with 15,000 cu.ft.-sec. it amounts to a gain of 1,500 brake horsepower.

From the forebay the water passes through steel-plate penstocks, 450 ft. long by 16 ft. diameter at the entrance and 14 ft. diameter at the Johnson valve to

FIG. 9. DIFFUSER WHERE CANAL ENLARGES INTO THE FOREBAY

55,000-hp. vertical-shaft Francis type turbines. The next article will describe these units.

All the engineering and construction work was done by the Commission's own engineers. Being so much larger than any other hydro-electric project ever undertaken, a great deal of pioneer engineering and construction work had to be done and much of the design work was checked by extensive experiments on large-sized models and new construction methods were devised.

During a major portion of the time that construction was under way, labor conditions were at their worst and much time was lost on account of labor shortage and strikes. However, in spite of these and many other handicaps, the project was carried to successful completion in record time and represents a distinct forward step in the art of hydro-electric engineering.

The present members of the Hydro-Electric Power Commission are Sir Adam Beck (chairman); Hon. Dougald Carmichael and Fred R. Miller. W. W. Pope is secretary and Frederick A. Gaby, chief engineer.

The surveys, hydraulic design and construction work were carried out under the supervision of Harry G. Acres, chief hydraulic engineer of the Commission, with whom were associated Thomas H. Hogg, assistant hydraulic engineer, Maxwell V. Sauer, designing engineer, James B. Goodwin, resident works engineer and George H. Angell, general superintendent of construction.

The electrical design and installation is handled entirely by the station section of the Commission's Electrical Engineering Department, which is in charge of Edgar T. J. Brandon, chief electrical engineer, assisted by Arthur H. Hull, electrical engineer, station section. T. R. Miller has been in charge of all electrical work on the Queenston generating station. The main and service generators and the main transformers are being installed by their respective manufacturers, but all other electrical equipment at the station is being installed by the Commission's construction department whose local staff is in charge of A. S. Robertson.

Power wishes to acknowledge the assistance and co-operation rendered the editor by the engineers of the Commission in the preparation of this article.

Fundamentals in Selection and Application of Electric Motors

GENERAL machine requirements and loads, characteristics of motors adapted to meet these requirements and general factors influencing motor selection, with brief mention of motor types and the ways in which they may be classified for selection.

By GORDON FOX
Electrical Engineer, Freyn, Brassert & Co., Chicago

TWO elements are involved when an electric motor imparts motion to the driven device; namely, torque and speed. These two combined represent power. Torque is a force exerted to overcome some opposing action. The opposing action, in the case of motor drive, comprises, in some degree, three factors: Work done by the driven machine in performing a useful function; work consumed in overcoming the friction of machine and motor; energy imparted in accelerating and consumed in retarding the moving elements of the motor and the machine.

Of these items the relative prominence differs according to the application. In a crane hoist, for instance, the useful work is the greater part of the load. In the case of a printing press the load is largely due to machine friction. In the case of a mill table or screw down in a steel mill, devices that are rapidly started, stopped and reversed, inertia of machine and motor are predominant factors. In every drive the presence and relative importance of all these elements of load should be considered.

Useful work performed by a machine often may be calculated quite closely as a problem in simple mechanics, based, for example, upon lifting a given weight a given distance, shearing a given area or pushing a definite stroke against a calculated opposing force. Data are also available for calculating the power required to remove metal, pump water, blow air or perform other useful work. Where there is no means of making calculations, test data or comparisons must be used in their stead.

Friction Load May Vary Materially

The friction load of machinery may vary materially, depending upon the condition of the gears, bearings and other members, alignment and lubrication. Most machinery involves about the same friction torque at all speeds, the variation due to speed being of lesser magnitude than other variables. It is possible to approximate by calculation the friction load of some machines. For practical reasons it is generally preferable to use test data or to compare with similar machines from which data are available. Friction load is sometimes expressed as an efficiency. For instance, it may be stated that a crane hoist has an efficiency of 70 per cent, meaning that 70 per cent of the total work is useful and 30 per cent friction, inertia being a negligible quantity.

The third element of load is due to the inertia that must be overcome in accelerating or retarding the motor and machinery. Inertia may be calculated from weights and radii of gyration of component members or determined by test or by comparison with known values of similar machines. Inertia is determined by test by noting the time required for a machine to drift to rest, retarded by its friction load, which may be measured. The formula used is

$$WR^2 = \frac{T \times t}{R.P.M. \times 0.003255}$$

where

WR^2 = Inertia at a given shaft in lb.-ft.^{2};
T = Friction torque at given shaft in lb.-ft.;
$R.P.M.$ = Revolutions per minute;
t = Time to drift to rest in seconds.

Inertia load involves change of kinetic energy. As it depends upon change of speed, it exists only in those portions of the operating cycle during which the speed changes. It is then present in an amount depending upon the rate of change of speed. Rapid acceleration or retardation involves rapid change of kinetic energy and a heavy inertia load. It is thus evident that the inertia load of a machine is not a definite value. It is a variable depending upon the rate of change of speed.

The torque demanded by a given machine may be steady and continuous. More commonly, it varies from time to time with changed conditions or fluctuates periodically through a more or less regular cycle of values. The motor must be capable of handling the sustained torque demand, both normal and occasional. It must also be able to develop sufficient overload or pull-out torque to handle any momentary demand peak such as may be incident to a given point in the cycle. Where torque fluctuation is excessive, it may be in order to consider equalization of demand through the use of a flywheel. This applies only to continuous running drives. In such cases, where pull-out torque is a determining factor, a flywheel may make possible the use of a smaller motor.

It is always desirable to determine what adjustments affect the torque demand. For instance, a small bandsaw will have its friction torque greatly increased by excess saw tension. A dry pan will cause a much heavier load with wet clay than with dry clay. A brick auger, if stopped long enough for the clay to set, will require excessive starting torque. In any case the limiting condition should be sought and a motor installed to handle this condition or else protective devices supplied to prevent the attempt.

Of interest also is the static torque which must be overcome in starting the machine from rest. Just as the demand during a cycle may vary, so the static torque may vary, depending upon the point in the cycle at which the machine is started. The static torque may involve friction only if the machine starts light or performs no work until speed is attained. On the other hand, starting torque may involve elements of useful load and particularly inertia load. Static torque and running torque may be closely similar or widely differing, depending upon static and running

friction and the character of the load. The static torque of a given machine may be determined by attaching a lever and weight or spring scale to a shaft or pulley and measuring the torque necessary to start movement.

The manner in which the load builds up as a machine accelerates may have an important bearing. For instance, a centrifugal fan has little friction load and starts easily. Acceleration involves an element of inertia load of some magnitude. As the fan acquires speed, the useful load comes into play. As a result of the combination of elements the current required by the motor during the starting period will be maintained or increased, whereas in the more common case the current, during acceleration, decreases. This action may have an influence on the motor. Particularly in the case of synchronous motors this holds true, as the static torque and pull-in torque must be properly related with respect to the load characteristics.

Speed Requirements of Driven Machines

Requirements of driven machines in the matter of speed are varied indeed. In an occasional instance speed is zero, that is, the motor produces torque only and moves through a small angle. The great majority of machines require more or less continuous operation at an approximately constant speed. In some cases close constancy or accuracy of speed is required, as for some textile drives and for paper machines and notably for such uses as mechanical rectifiers and synchronous-motor-driven clocks. Somewhat less common are the machines requiring adjustable speed; namely, a constantly maintained speed at selective values. Where adjustable speed is desired, the range may be either narrow or wide. More commonly, a range of two to one or four to one covers the requirements. Sometimes the range may be much greater. In the case of adjustable speed it may be desired to have particularly good regulation over a given portion of the range. Multi-speed is used to designate practically constant-speed operation at a few definite values with little or no adjustment between these values. The multi-speed motor does not fulfill any requirement that the adjustable-speed motor cannot meet, but is used because of its availability for alternating-current circuits.

When the load imposed by a driven machine is steady and continuous, it serves as a direct measure of motor capacity required. When the loads vary or fluctuate, the condition is more complicated. Loads may fluctuate in a regular manner through a cycle of values, as in a metal planer, where reversing, cutting and return-stroke periods impose differing demands. Loads may fluctuate in irregular manner as in the case of a grinding wheel or rock crusher. The great majority of loads are subject to changes brought on by different materials handled or different details in operations performed from time to time.

In the case of adjustable-speed, multi-speed or varying-speed motors it is desirable to consider what load changes are brought on by changes in speed. In the case of a printing press or conveyor in which the load is largely friction, the torque will usually remain approximately constant at all speeds and the horsepower demand will increase about in direct proportion to the speed. This is called a constant-torque drive, and the motor must exert its maximum power at its maximum speed point. In a rolling mill where heavy sections are rolled at the lower speeds and lighter sections at the higher speeds, the horsepower demand may be approximately the same for all speed points. The load demand of a centrifugal fan increases about as the cube of the speed; so that the load at low speeds is comparatively light. These are but a few examples of load characteristics which should be considered as bearing on motor and control selection.

Capacity of a motor is determined in part by its heating. This in turn depends on the rate at which losses within the motor release heat energy and the rate at which this heat is radiated or conveyed from the motor surfaces. The losses in a motor comprise two elements —those that are more or less constant, such as magnetization, friction and windage, and those that vary with the load, such as copper loss. Owing to the fact that copper losses (I^2R) are proportional to the square of the load current, it is commonly considered that the heating is about proportional to the root mean square current; that is, the square root of the sum of the squares of momentary-current values, taking into consideration the duration of these values. The rating of a motor required for a given duty is therefore often determined on the basis of the r.m.s. (root mean square) current. Where power and current are approximately proportional, the motor horsepower required may be based on the r.m.s. value of power.

In determining motor size by the r.m.s. method, the fact must be considered that when the motor is at rest or running slowly, it does not dissipate heat as rapidly as when running at normal speed. Therefore, in cycles of operation that include rest periods, it is necessary to discount for the decreased rate of heat dissipation. It is usual to consider that the cooling rate at standstill is about one-half to one-third of the full-speed value, so that, in taking the time of a cycle to determine the average heating, only one-half or one-third of the rest period is considered. It is commonly considered that an open-type motor will dissipate at standstill one-third that when running. An inclosed motor will dissipate at standstill one-half the heat dissipated when running. The practice is frequently followed to consider the cooling rate of standstill as one-quarter that when running and to consider the cooling rate during acceleration and deceleration periods as one-half that when running full speed.

This general method of motor selection may best be shown by an example. Let us consider the case of a grab-bucket hoist involving the following load cycle:

Action	Period, Sec.	Output, Hp.
Close bucket	6	40
Hoist	10	80
Open bucket	3	30
Lower bucket	10	45
Rest	16	0

The r.m.s. load =

$$\sqrt{\frac{(40^2 \times 6) + (80^2 \times 10) + (30^2 \times 3) + (45^2 \times 10)}{6 + 10 + 3 + 10 + \frac{16}{3}}}$$

$$= 53 \textit{ horsepower.}$$

According to this calculation, an open-type motor having a continuous rating of 53 hp. would handle the bucket performing its cycle in continuous repetition.

Owing to approximations as to variation of losses with load and variation of heat-dissipating ability, the r.m.s. method of selecting motor size is not entirely accurate. However, the data upon which the calculations are based, are usually more or less approximate,

justifying the method. For some motors of standard designs data are available for computation of motor size by the loss method. This is done by comparing the losses with the heat-dissipating ability of the motor. This method may be best shown by an example that will consider the bucket hoist previously mentioned. Fig. 1 shows the characteristic curves of a motor suitable for this work and of a size known to be approximately correct. The ability of the motor to handle the load will be checked.

Action	Period, Seconds	Output, Horsepower	Watts Loss From Curve	Watts Lost Seconds
Close bucket	6	40	4,200	25,200
Hoist	10	80	10,400	104,000
Open bucket	3	30	3,500	10,650
Lower	10	45	4,650	46,500
Rest	16	0	0	0
Total	45			186,350

The values of watts lost corresponding to horsepower output are taken from the motor curves, as indicated by the dotted lines. The total running time is $6 + 10 + 3 + 10 = 29$ seconds. The average loss per second while running is $186{,}350 \div 29 = 6{,}426$ watts. From the motor curves it will be found that 6,426 watts loss per second while running will not heat the motor above 75 deg. C. rise, provided the running time is not more than 65 per cent of the total time, as indicated by the dotted line *A*. In the case mentioned the running time is $\frac{29}{45} \times 100 = 64$ per cent of the total time. Therefore the motor will not overheat under this duty continuously repeated. This motor has a continuous rating of 55 hp., which checks closely with the previous calculation on the r.m.s. basis.

In many cases, particularly when load fluctuations are not severe, the motor size may be based on average load. This method is particularly convenient in making a test wherein the average load may be determined from the power consumption for a given period as determined by the watt-hour meter, this value being translated into motor output by correcting for average motor efficiency. If a motor is called upon to retard, as by dynamic braking or plugging, these factors must be taken into consideration, as they have a material influence on motor heating.

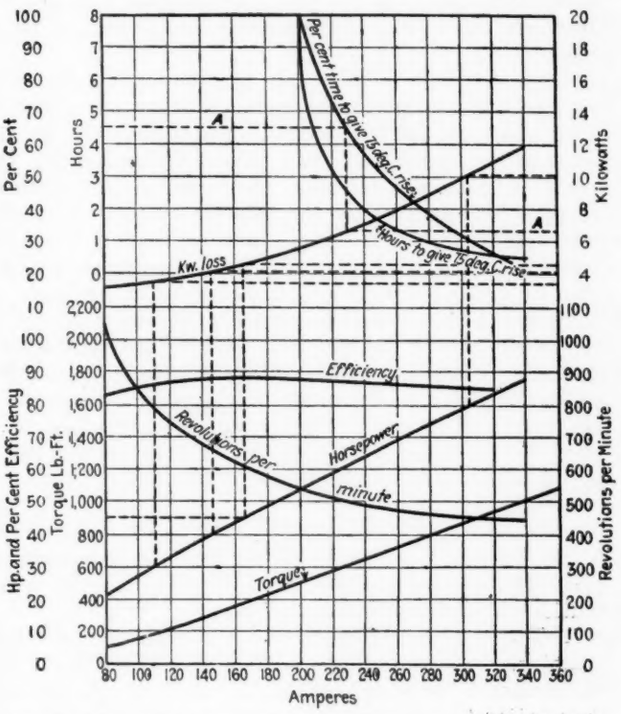
Classification of Motors

In distinguishing between motors perhaps the broadest classification is made with reference to the electric system; namely, direct-current, polyphase alternating-current and single-phase alternating-current. The use of single-phase motors is largely restricted to applications where this type of service is most readily available, particularly in the smaller sizes, 15 hp. and below.

Motors are often classified as to their speed characteristic, as constant-speed, adjustable-speed, multi-speed or varying-speed machines. The definitions of these terms have already been outlined in connection with service requirements.

Motors of similar electrical characteristics may differ widely in their mechanical features. The prevailing type is the so-called general-utility motor of rather light construction for use primarily in industrial service where requirements are not severe. A more substantially built motor, designed particularly for crane and hoist duty, is quite generally applied, particularly in the smaller sizes. Mill-type motors were developed particularly for steel-mill duty. They have small-diameter armatures of low inertia and are of the most sturdy and accessible construction throughout. An alternating-current machine of substantial mechanical design is available, designated as the mill-type motor. The railway type is designed particularly for suspension from car axles and for accessibility from repair pits under the car. A special type is designed for mine locomotives. Here the narrow wheel gage limits the available space and forces a compact design. There are also many special types developed for specific purposes, such, for instance, as the textile motor.

Motors that are intended for fairly continuous duty at approximately full load, are continuous rated. They are not intended to develop or handle mechanically loads greatly in excess of their rating based on continuous-duty heating. Where the service of a motor is intermittent, it is not necessary that it be able to dissipate



CHARACTERISTIC CURVES OF 60-HP. 485 R.P.M. 230-VOLT MILL-TYPE SERIES MOTOR, WITH 60-MINUTE RATING

continuously losses developed during short intervals of operation. So-called "intermittent duty" motors are so designed that they are able, both mechanically and electrically, to develop powers in excess of their continuous heat-dissipating ability. Intermittent ratings are based on the period of time during which a motor will develop full load and attain a given temperature rise in so doing. Based on a 75 deg. C. rise, the motor whose characteristics are shown in the figure might be rated at 93 hp. for 30 min., 75 hp. for 60 min., or 65 hp. for 120 min. This motor also might be used for continuous service, in which case it would develop 55 hp. with a 75 deg. C. rise. It will be seen that if a motor of this type is used for continuous service, its full mechanical and electrical capabilities are not realized by reason of the restriction placed by heating. More effective use of the motor might then be made through the use of artificial cooling, which might permit the motor to develop continuously perhaps 75 or 80 horsepower.

A Practical Way To Test Lubricating Oils For Frictional Losses

By W. F. OSBORNE
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AT SOME time in every engineer's career he is called upon to test lubricating oils to determine which of two or more oils is the most suitable for his equipment. The value of the test he makes will be determined largely by the accuracy of the data he secures and the relative importance of the various factors in making the decision.

Two kinds of tests can be made, one in which the lubricating value of the oil is determined and another in which the life and consumption of the oil are measured.

In power-plant oil tests, it is practically impossible to measure the frictional horsepower of any machine accurately enough to indicate the difference in the lubricating quality of two oils. Consequently, the engineer must depend upon the bearing temperatures to give him an idea of the relative suitability of the oils. As explained in *Power*, June 13, bearing temperatures are sometimes very difficult to measure, but the plan of drilling a hole into the bearing at an angle of forty-five degrees and inserting a thermometer close to the surface of the metal is probably as satisfactory as any. In the circulatory oiling system, the quantity of oil circulated has a great influence on bearing temperature, and in order to get results of any value, it is necessary to measure the amount of heat carried away by the oil and by the cooling water when this is used.

Readings to be Taken

The readings necessary to indicate the comparative value of two oils in a circulatory system and the precautions to be taken are as follows:

1. Temperature of engine-room atmosphere near the machine. All possibility of drafts affecting the thermometer readings should be carefully eliminated. It is better to take the atmosphere temperature at two or three places near the machine and to use the average of these readings.

2. Temperature of oil just before it is delivered to the bearings. If coolers and heaters are available, it is best to regulate them so that the temperature of the oil going to the bearings will be the same on each test.

3. Temperature of the oil as it leaves each bearing. The best method is to immerse the thermometer directly in the stream of oil leaving the bearing.

4. Quantity of oil in pounds per minute flowing to each bearing. This can be determined by catching the oil as it leaves the bearing and measuring the time required to collect one quart or one gallon. It may be easier on some installations to measure the oil as it goes to the bearing. Endeavor to regulate the quantity of oil so that it will be exactly the same on each test.

5. Temperature of cooling water going to bearings. Insert thermometer in the water line at some point near the machine. Try to have the temperature the same on each test.

6. Temperature of cooling water leaving each bearing.

7. Quantity of water in pounds per minute flowing to each bearing. If this cannot be measured for each bearing individually, it should be measured for the entire unit by a suitable meter on the line going to the machine. Try to have the quantity the same on each test.

8. Temperature of bearing measured by thermometer inserted in hole drilled into bearing as near the rubbing surface as possible, or by thermo-couple embedded in bearing metal.

Heat Carried Away from Bearing

The temperature of the bearing will be determined by the frictional heat, conducted to or from the bearing from outside sources, modified by the amount of heat absorbed and carried away by the oil and the cooling water. The quantity of heat absorbed by the oil is equal to the outgoing oil temperature minus the incoming temperature multiplied by the quantity of oil going through the bearing in pounds per minute times the specific heat of the oil (varies from 0.43 to 0.48), or $H = (T_o - T_i)WS$ when

T_o = outgoing oil temperature,
T_i = incoming oil temperature,
W = weight of oil circulated per minute, and
s = specific heat of oil (0.43 to 0.48).

The quantity of heat absorbed by the cooling water is equal to the outgoing temperature minus the incoming temperature multiplied by the quantity in pounds per minute times the specific heat of water (1).

In order to eliminate the variation in conducted heat from steam cylinders, generator armatures, turbine casings, etc., the tests should always be made under identical conditions of load and steam temperature. Since the frictional heat varies with the speed, the machine should be run at constant speed for comparative tests.

By eliminating these variable we now have only four quantities to consider, the atmospheric temperature, the bearing temperature, the quantity of heat carried away by the oil and the quantity of heat carried away by the cooling water. The difference between the bearing temperature and the atmospheric temperature indicates the rise due to frictional heat. When the sum of the B.t.u. carried away by the oil and the cooling water are equal on two tests, the oil that shows the lowest temperature rise in the bearing evidently will produce the lowest friction. If the temperature rise is exactly the same on two tests, the oil that produces the least amount of heat to be carried away by the oil and water has caused the least friction.

Precautions to be Observed

The method of conducting the test and the regulation of the variables depends a good deal upon the individual installation and the means available for regulating the influencing factors. One way to do it is to maintain a constant supply of oil to the bearings and regulate the cooling water so that the temperature rise of the bearing above the atmosphere is exactly the same on each test. Then the best oil can be determined

directly by calculating the amount of heat carried away by the cooling water and the oil. As an example let us suppose that we have made the following measurements on a steam-turbine circulatory system:

	Oil No. 1	Oil No. 2
Temperature of air on right-hand side, deg. F.	70	65
Temperature of air on left-hand side, deg. F.	75	69
Average temperature of air, deg. F.	72.5	67
Temperature of oil to bearings, deg. F.	125	125
Temperature of oil from bearings, No. 1 bearing, deg. F.	135	132
Temperature of oil from bearings, No. 2 bearing, deg. F.	145	141
Temperature of bearings, No. 1 bearing, deg. F.	160	155
Temperature of bearings, No. 2 bearing, deg. F.	170	164
Temperature of water to bearings, deg. F.	65	63
Temperature of water from bearings, No. 1 bearing, deg. F.	80	86
Temperature of water from bearing, No. 2 bearing, deg. F.	83	88
Quantity of oil to bearings per minute, No. 1 bearing, lb.	3.8	3.8
Quantity of oil to bearings per minute, No. 2 bearing, lb.	4.56	4.56
Quantity of water per minute to bearings, lb.	8.3	8.3
Heat carried away by oil per minute, No. 1 bearing, B.t.u.	17.1	12.0
Heat carried away by oil per minute, No. 2 bearing, B.t.u.	41.0	32.8
Heat carried away by water per minute, No. 1 bearing, B.t.u.	125.5	190.9
Heat carried away by water per minute, No. 2 bearing, B.t.u.	149.4	207.5
Total heat carried from bearing, No. 1 bearing, B.t.u.	142.6	202.9
Total heat carried from bearing, No. 2 bearing, B.t.u.	190.4	240.3
Total heat from both bearings, B.t.u.	333.0	443.2
Bearing temperature rise, No. 1 bearing, deg. F.	87.5	88.0
Bearing temperature rise, No. 2 bearing, deg. F.	97.5	97.0

From this test we learn that although the bearing temperatures were lower when using oil No. 2 than when using oil No. 1, the temperature rise was about equal, and the actual amount of heat generated in the bearing was greater when using oil No. 2 than when using oil No. 1. When making such a test, of course the operating conditions must remain constant in order to eliminate as many variables as possible.

If we had contented ourselves with simply measuring bearing temperatures, we would have come to the conclusion that oil No. 2 was the best. If we had stopped with measuring the temperature rise in each bearing, we would have thought that the two oils were of equal lubricating value, but when we go a little farther, we find that there is quite a difference in the value of the oils, oil No. 1 being much the better oil for this particular installation.

The Absolute Pressure Gage—Its Construction and Use

BY V. P. GRIFFIN

The absolute pressure gage is seldom thought of as a practical instrument for use in testing condensers and air pumps. It is usually looked upon as an expensive and delicate laboratory instrument, and the less practical mercury gage of the barometer type is generally used in its stead.

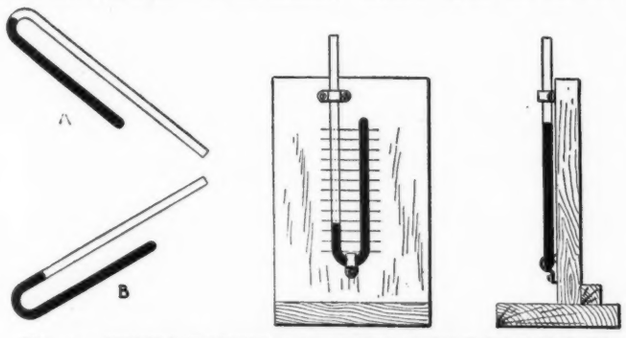


FIG. 1. SHOWS POSITION OF TUBE WHILE BOILING TO REMOVE AIR, AND SIMPLE FORM OF MOUNTING

The advantages of the absolute pressure gage are that it requires no capillary, temperature, elevation or barometric corrections. Anyone who has had occasion to make these corrections knows how difficult they are to apply with the necessary degree of refinement, especially the capillary correction. And besides these advantages, the gage can be located in close proximity to the point where the desired determination is to be made, thus eliminating trouble from leaky piping.

Several of these gages can be made in a short time with a gasoline blow-torch and a supply of glass tubing,

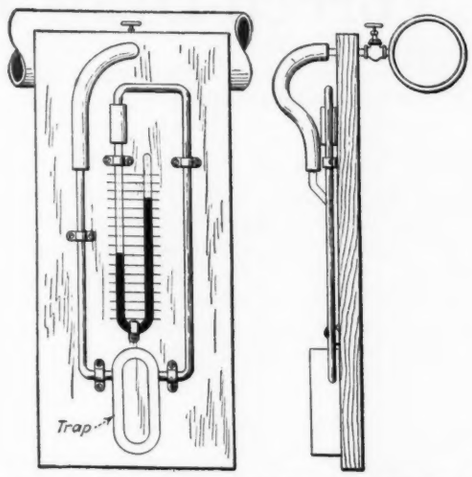


FIG. 2. SHOWS GAGE MOUNTED AND FITTED WITH CONDENSATION TRAP

clean mercury and the necessary material from which to construct the stands and scales. The essential feature is to get the closed end of the tube entirely free of air. This can be done by filling the tube to a point as shown by *A*, Fig. 1, and boiling the mercury vigorously while in this position, and then tipping the tube and adding more mercury and boiling it while in the position shown by *B*. Once the tubes are made and filled, they can be mounted as elaborately as desired. In Fig. 1 is shown a simple and convenient mounting. It can be set on a convenient flat surface or tied to a pressure connection on the side of a condenser shell. A scale made of graph paper with twenty divisions per inch can be read to within 0.02 of an inch. The writer has had occasion to use a dozen or more of these gages on a single test.

Fig. 2 shows a more elaborate mounting. This gage is designed especially for testing air pumps of the LeBlanc type. A trap is used in this case to prevent water from being drawn into the gage should the vacuum be lost during the test. The gage and trap are both mounted on the same board, which is hung on the test connection as shown by the illustration.

Work is defined as force times distance. The work done in pumping water is the weight of water pumped multiplied by the vertical distance (or its equivalent) that the water is raised. For example, the work done in raising 1,200 lb. of water through a vertical distance of 50 ft. is $1{,}200 \times 50 = 60{,}000$ ft.-lb. Pumping water against a suction or discharge pressure is equivalent to lifting it against gravity, each pound per square inch of pressure or suction counting as 2.3 ft. of lift, or "head." Suppose that a gage at the pump discharge shows a pressure of 140 lb. and that the center of this gage is 8 ft. above the water level in an open tank from which water is being pumped. Then the total "head" pumped against (not counting the friction in the suction pipe) is $8 + 140 \times 2.3 = 8 + 322 = 330$ ft.

Operating Characteristics of Forced-Draft Fans

THE increasing use of underfeed stokers operating at high ratings has resulted in the development of new types of forced-draft fans driven by motors or turbines and designed to give reliable service and good efficiency at high rotative speeds. The latest development has been a type of fan with a maximum horsepower which is in general only five or six per cent higher than the rated horsepower.

By H. E. CORL
Mechanical Engineer, Wm. Steele & Sons Co.

DURING comparatively recent years the fan manufacturers have had to develop a new line of forced-draft equipment in order to keep pace with the underfeed stoker, which, when operating boilers at 300 per cent of rating, may require a static pressure of 6 in. in the windbox. The ordinary type of fan was of far too light construction to withstand the much higher rotative speeds required by this higher pressure. Moreover, fans as previously designed had such characteristics that they became objectionably large where they had to meet the new conditions. In addition to all this the reciprocating engines then generally in use for driving the fans were unable to meet the new speeds required.

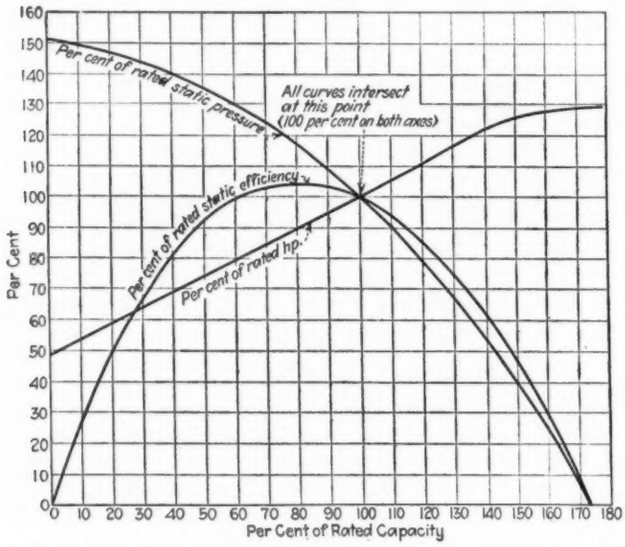

Per cent of rated static pressure
All curves intersect at this point (100 per cent on both axes)
Per cent of rated static efficiency
Per cent of rated hp.
Per Cent
Per Cent of Rated Capacity

FIG. 1. CHARACTERISTIC CURVES OF OLDER TYPES OF HIGH-SPEED FORCED-DRAFT FANS, SHOWING MAXIMUM POWER 30 PER CENT ABOVE RATED POWER

These circumstances led very quickly to the development of the present type of fan with its sturdy construction and peripheral speeds ranging from 8,000 to 17,000 ft. per min. (900 to 5,000 r.p.m. with the size of wheels in use). With such speeds the fans are ordinarily driven by steam turbines or direct-connected motors. In some cases both are attached to one fan as a double drive, to meet the requirements of breakdown service and heat balance.

In modern service the static discharge pressure may vary from practically zero up to the maximum pressure required for the desired rating. Moreover, the fan operates at varying speeds and under the control of varying steam pressures. There are times when, with the fan operating at full or rated speed, the static pressure may suddenly drop off to a very low value, owing to such an event as the throwing open of all dampers in an emergency. At such times fan-motor fuses or breakers may blow and other things happen.

Referring to Fig. 1 (which shows typical characteristics of a fan not of the latest construction), it will be seen that, as the static pressure drops, the horsepower curve goes up in nearly a straight line with only a slight droop at the end where the pressure is very low. The point where all three curves intersect is the point of normal or rated capacity, pressure and power. That is to say, for a fan rated at 50,000 cu.ft. per min. at 4 in. static pressure and requiring 65 hp. at rating, these values would be represented on the curves as 100 per cent, and any variation from them would be read in percentage of these values.

Using the figures just given, it will be noted that in dropping from 4 in. static pressure down to 1 in., which is 25 per cent of rating, the power curve rises from 100 per cent to 127 per cent, or the power becomes 82.5 hp. (65 × 1.27). Thus it will be seen that if 4 in. were the desired operating pressure, and a 75-hp. motor were employed to drive the fan (the latter having a normal load of 65 hp.), the motor would be overloaded by 7½ hp. if the static pressure should fall to 1 in. With further reduction in static pressure this would become even worse.

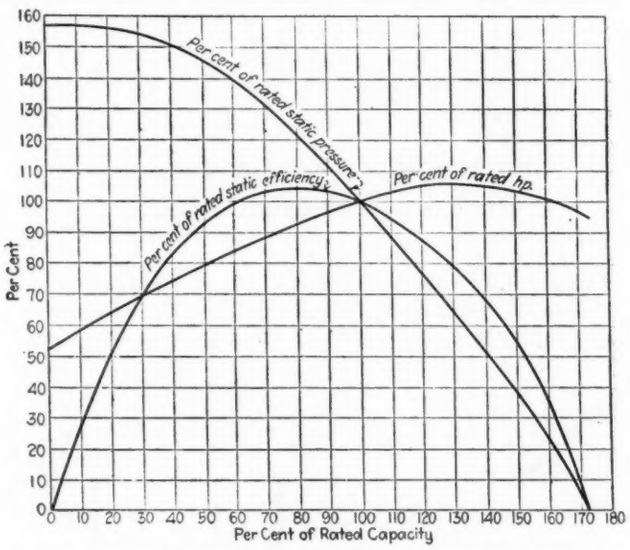

Per cent of rated static pressure
Per cent of rated static efficiency
Per cent of rated hp.
Per Cent
Per Cent of Rated Capacity

FIG. 2. CHARACTERISTIC CURVES OF NEWER TYPES OF HIGH-SPEED FORCED-DRAFT FANS, SHOWING MAXIMUM POWER ONLY 6 PER CENT ABOVE RATED POWER

Another objection to a fan with the characteristics shown in Fig. 1 is that if the fan is driven by a con-

stant-speed alternating-current motor, using one large enough to care for accidental reduction in static pressure below normal, the motor is normally much underloaded and consequently runs at low efficiency and power factor.

To overcome this objection, most of the fan manufacturers have developed during the last few years, fans with so-called non-overloading characteristic. The characteristic curves of such a fan are shown in Fig. 2. Note that the power curve does not rise more than five or six per cent above normal, and that it actually drops back under normal after the static pressure falls below 35 per cent of the rated pressure.

With this excellent power characteristic it is possible to use a motor of a size close to the normal or rated horsepower of the fan, and one that will operate at high efficiency and give a good power factor. Furthermore, a motor connected to such a fan cannot be damaged by a bad overload, due to drop in pressure.

There are two general methods of controlling forced draft to stokers. One is to vary the speed of the fan as the steam pressure changes, this being usually accomplished by means of speed-control apparatus governed by the steam pressure. The other method of control is by means of dampers. Damper regulation may be by hand or by a main damper automatically operated from the steam pressure by a damper regulator. With damper regulation the fan is operated at constant rated speed.

With other conditions remaining the same, the horsepower required to drive a fan will vary as the cube of the speed, and the air pressure as the square. For that reason it is more economical to control the fan by speed, as the power drops off very rapidly when the speed is decreased.

For the second method of control, where the speed is constant, the fan performance can be traced from Figs. 1 and 2. When the dampers close, owing to high steam pressure, it is evident that the static pressure builds up and the air delivery decreases. This is accompanied by a decrease in power up to the point of no delivery, which is also the point of maximum static pressure. The power at this point of no delivery is usually about 50 per cent of the rated power. The decrease in power under this form of draft control is thus seen not to be as great as for the other method of control where the fan speed is reduced.

In large power stations the practice of using an individual forced-draft fan for each boiler with variable-speed control is coming more generally into favor, and from a study of the performance of such fans this would seem to be the most economical arrangement.

Terminating Conduits at the Switchboard

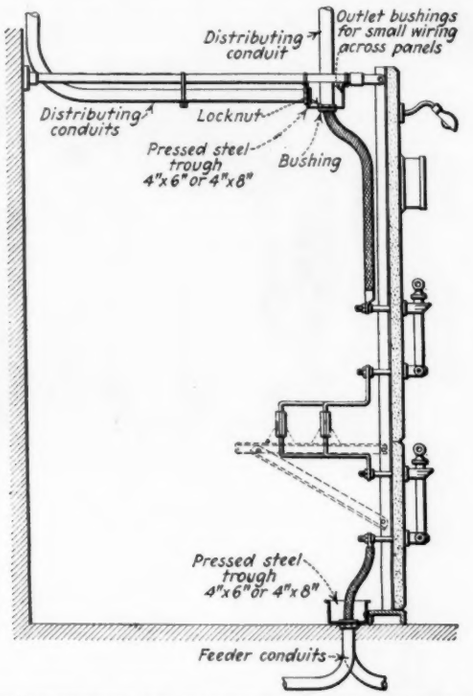
By William Sheriff Jones

The termination of feeder and distributing-circuit conduits at the switchboard is a matter that should be given more forethought in the design and greater care in the installation. It is not unusual to see installations in which the conduits are arranged haphazard, with no attempt at lining up and with ineffective and temporary methods of bonding and grounding.

The grounding of conduits and other non-current carrying, exposed, metal parts of an electrical installation is an important consideration, and the method employed should be one which will insure effectiveness and permanency. The arrangement provided for should permit extension or alteration of the system in such a manner that the bonding-ground connections, on the parts that are not effected by the extension or alteration, will not be disturbed.

Frequently, the ground connection is broken or loosened during the work of making changes at the switchboard, and this condition does not become evident until the trouble that the ground is intended to protect against, occurs.

The accompanying figure shows a method whereby conduits may be properly lined up, permanently secured in alignment and effectively bonded together and grounded. The arrangement shown also provides means of readily taking care of small wiring, such as instrument leads, wires for switchboard bracket lights and other connections which cross from one panel to another.



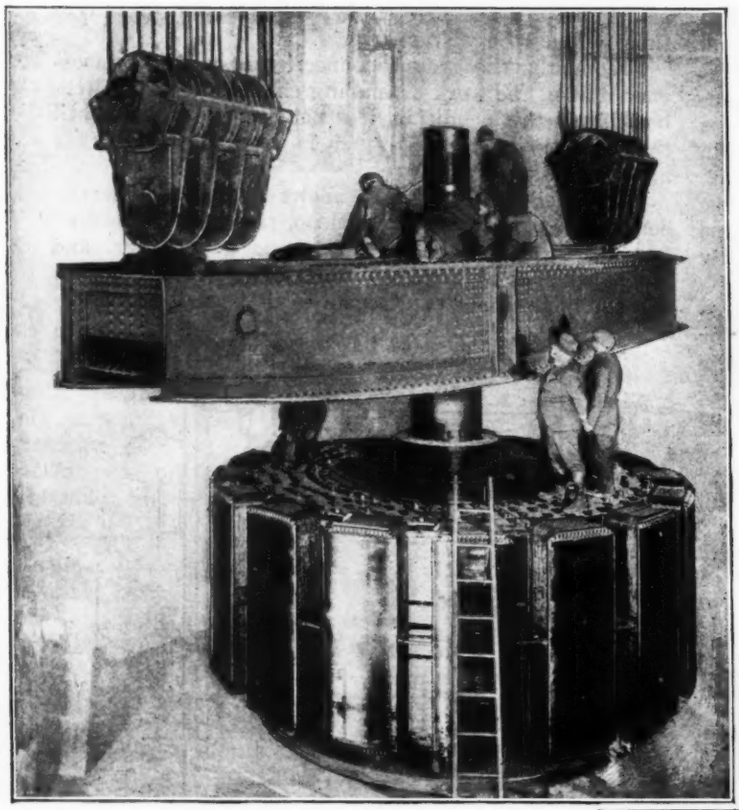
ARRANGEMENT OF CONDUIT AND WIRING BACK OF SWITCHBOARD

It will be noticed that the proposed scheme provides a bonding method whereby the steel framework of the switchboard and all conduits are electrically connected together in a permanent, workmanlike manner. One connection to ground, from the switchboard frame or from any one of the conduits, will ground all conduits and the frame.

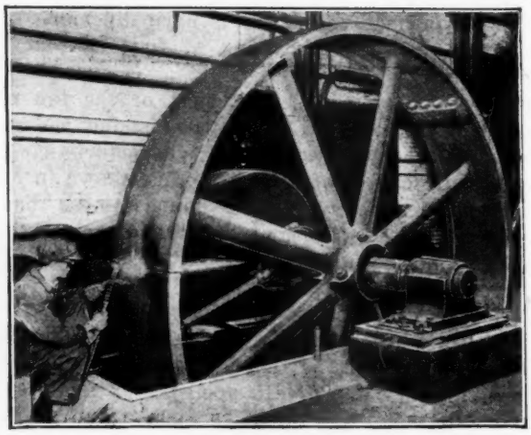
The metal trough at the floor line of the switchboard, which is provided to take care of distributing and incoming feeders that are run under the floor, also serves as a protection for the cable against mechanical injury.

In designing the troughs for any installation, provision should be made for future extension, by arranging for additional conduit openings in them.

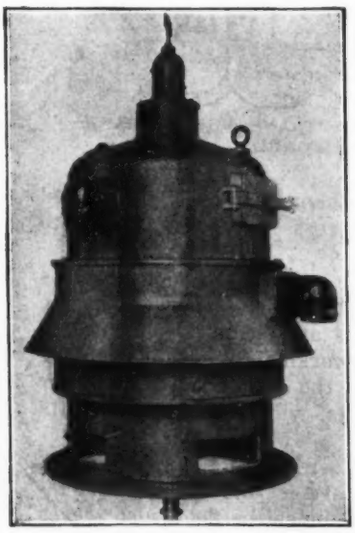
There is much wisdom in the following sentence taken from the book, "Engineering of Power Plants," by Fernald and Orrok. "No better service can be rendered the non-expert about to construct a power plant than to advise him to engage a capable engineer to design the plant and to superintend its installation."



Lifting, moving and placing a 615,000-lb. rotor for one of the 55,000-hp. hydro-electric units at the Queenston (Ont.) plant. See the article on this plant in this issue of *Power*.



Sometimes it is a puzzling question, when tearing down a plant, whether to sell a large casting for further service or to break it up and sell it as scrap. In the case of the flywheel shown here, the expense of rigging up a scaffolding to remove this large casting would have been so great that it was found more profitable to cut it up into small pieces and sell it as junk. An Oxweld operator is shown making the first cut in the rim by the oxyacetylene process. The contractor's own operator did the rest, consisting of seven additional cuts through the rim and a cut through each spoke.

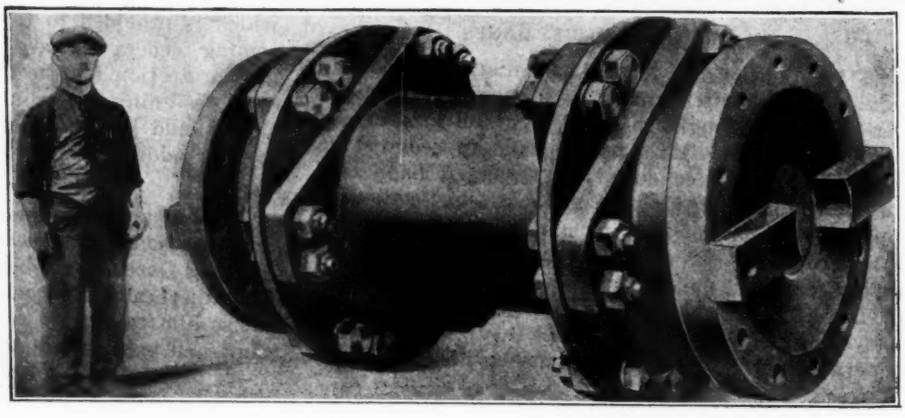


Not a German helmet, but a 440-volt G.E. vertical induction motor with indicator and a special stator frame, designed for outdoor service.

Here are the remains of a cast-iron boiler that was not built to meet the steam-boiler rules of Erie, Pa., where it blew up not long ago. It was used for vulcanizing and was under 50 lb. pressure just before the explosion, although the A. S. M. E. Code permits only 15 lb. for cast-iron boilers. The thickness of the casting varied from ¼ in. to ¾ in., and it is thought likely that the expansion and contraction resulting from this varying thickness was the cause of the accident.

□ □ □

A flexible coupling that transmits 10,000 hp. at 100 r.p.m. with a factor of safety of five. It connects an electric motor to a 132-in. plate mill in one of the plants of the Brier Hill Steel Co., of Youngstown, Ohio, and was built by the Thomas Flexible Coupling Co., of Warren, Pa. The coupling weighs 28,000 lb. and has a capacity for parallel misalignment of ½ in. and endwise float of 1 in.



Cleaning Inspirator Tubes Produced Different Results

By H. D. Yoder

Some months ago a reader asked why he had been able to repair one injector by passing a drill through delivery jet parallel bore, when another similar injector failed when treated in the same manner. Not having seen a reply to his question, the following trouble data are offered.

Of course not every injector fails for the same reason, but assume that the two injectors mentioned had both been affected by the same trouble, even then, the same apparent thing may be done to both and still different results be secured. Injector testing, especially in experimental work, is so involved with apparent and real factors that the injector has been accused of ghost-like qualities, and it is difficult to set any single agent at work and know that no other agents have crowded themselves in also.

Obstruction in Jets

For instance, both injectors may be in the same condition. The same drill may be passed through both delivery jets. Yet, in the reassembly one jet may be assembled with dirt under the seat, or when steam is turned on a piece of scale may come down and lodge in one of the jets. Apparently, then, both injectors are in the same condition; actually, they are not.

It has even happened that an operator would remove the injector and thoroughly clean out all jets. Then when steam is turned on again, another slug of scale may come down into the jets. The operator, of course, protests that the injector is clean; actually, the injector is again full of dirt.

Assume both injectors were for the same size pipe, there is still a chance that the jets may be different. Standard makes of injectors usually are made in two sizes for each nominal pipe diameter, this plan giving two sets of jets for each pipe size, which interchange in the same injector body. Therefore, a ¾-in. injector body might have two different delivery jets and require two different drills. In this case the drill that is right for one set of jets would be wrong for the other.

The delivery-jet parallel bore is the basic dimension of the injector and is very sensitive. Its relation to the steam-jet parallel bore is quite definitely fixed in standard commercial injectors as follows: Approximately 1.4 times the delivery jet bore equals the steam-jet bore.

Or, granted both injectors had the same jet sizes, one may have had the transverse spill holes still limed up (if this type of injector was designed with spill holes) while the other one, after being drilled, may have had scale removed from both parallel bore and spill holes.

Spill Holes in Automatic Injectors Relieve Jet Congestion

The automatic type of injector is designed with transverse spill holes in the delivery jet just above the parallel bore. These spills are to relieve jet congestion just before the injector has established or reached the stage where steam and water have mixed in just the right proportions to enable the injector to go to work. These spill holes are essential for starting only, being detrimental after the injector has once established or commenced to work. Hence, if the spills were choked up, the injector would not start until the steam pressure was quite high. The spills enable an injector to start on a lower range of steam pressure.

Or both injectors may have been in the same condition, needing the same repairs; yet one may be installed in line again with a new suction air leak which will cause this one to fail; one may receive a fresh slug of scale and, of course, refuse to work; one may be re-assembled improperly; one may have had the water supply temporarily throttled for some reason; or some operating condition may have changed unobserved to the operator. Again, the two injectors may have failed originally for two different reasons. In this case both injectors could not be expected to be repaired in the same way.

Operation Governed by Definite Principles

Injectors operate upon definite principles which have been established by years of service. For this reason the injector always works with certain definite conditions and fails with other conditions.

Experience, is of course, a great help in analyzing these conditions, but anyone who works conscientiously through the classification of injector troubles, shown by the table, will be reasonably sure to discover any trouble.

It has been asserted that 90 per cent of injector troubles originate in the suction line, hence the suction line should be first investigated. A convincing way to check up the suction line entire is to make up a master suction line. This test line should have minimum joints and length and each part should be put up with the greatest care and tested for airtightness. This short master suction need only comprise progressively an injector nut and tailpipe, a street elbow, a globe valve well packed, a short pipe, just long enough to extend down into a large pail of water. The completed line can be easily tested by opening the valve, holding one end tight shut and sucking a vacuum on the open end by mouth to see if it is airtight. Then disconnect the old suction line and connect the master suction. Set the large pail of water with the master suction line submerged and try the injector. If the injector works, it proves that the trouble was in the old suction line.

Requirements of Correct Assembly

If the injector does not work, it will be well to examine the injector itself as thoroughly as possible, before going further. A correct injector assembly requires that: the injector must be suitable for the required service; the overflow valve be airtight; the jets clean and free from dirt in all of the passages. In the automatic-type of injector the gravity delivery ring valve must be free to function and must seat watertight; the surface against which the ring valve seats must also be a smooth seat. All jets must have smooth, perfect seats, also smooth body surfaces against which they seat. The jets must line up with each other—some makes are provided with a floating delivery jet which can be aligned directly under the suction jet before the plug is finally tightened down. In setting the jets, see that there is no dirt between any of the jet seats and the body seats. Some injectors have a flanged slip-joint steam jet which has been known to drop out if the operator is careless in handling the injector. Note if all tailpipes are making good seats on the injector body. The injector body must be airtight throughout the casing; sometimes hammering or freezing may start a leak. Jets must, of course, be in good condition, and not work out. Examine the delivery jet, especially where the greatest wear occurs;

also the suction jet. If possible, interchange an injector known to be in working condition, as this will indicate whether further line trouble need be investigated.

If an injector known to be in working condition does not operate on this installation, or the injector itself seems to be in good condition, again attach the master suction and try once more after the injector has been re-assembled. If, the injector still refuses to work, leave the master suction line attached to the injector and set up a master delivery line, built up progressively as follows: An injector nut and tailpipe, a coupling, a nipple, a tee, a nipple, a globe valve and a discharge nipple with street ell. Into the tee is screwed a siphon pipe and pressure gage.

Then disconnect the regular delivery line and turn the injector so that the master delivery can be attached. Start the injector with the master delivery valve open, then throttle the valve until the pressure gage shows that the injector is working against a resistance equal to the steam pressure, or 10 to 20 per cent greater.

If the injector now works properly it means that the old delivery line resistance was greater than 110-120 per cent of the steam pressure and the resistance should be located. Or it may also mean that the trouble was in the old suction and delivery lines both, and in this case the old suction connection, along with the master delivery line, would serve to eliminate one of the possibilities and locate the trouble definitely.

Condition and Quantity of Steam

Assuming that the injector is not yet working properly, the next question is to learn if the injector is getting enough steam in good condition. This involves the following questions: Is the boiler large enough to supply steam at a constant pressure? Is the steam of average quality or is it unusually wet, owing to boiler conditions? Is the boiler too full, or flooded with water?

Next, it is necessary to know whether the steam line is actually giving enough steam. To determine this question, take down the steam line, rap the pipes free from scale, ream the burred pipe ends to full pipe size, see that the steam pipe does not screw into the steam valve so far as to choke the area, and that a good full-flow valve is used.

The foregoing covers the worst of cases in a slow and sure manner, but very often common sense will greatly shorten the process. Pipe for injector installations should be rapped out or sandblasted free of scale and all ends reamed clear of burrs.

Classified Injector Service Troubles

Condition—Overflow Discharging no Steam or Water, or but Little Water. Location of Trouble.

Injector

Suction jet plugged up.
Steam jet plugged up.
Overflow valve clamped shut.
Interior limed up badly.
Gravity ring valve on delivery jet not open.

Steam Line

Steam line choked.
Steam valve not opened.

Overflow

Overflow plugged up or closed up with a valve.
Overflow connected to closed vessel.
Overflow valve not opening up properly.

Condition—Overflow Discharging Steam but no Water. Location of Trouble.

Injector

Overheated because of delivery-boiler check leak.
Overheated due to steam-valve leak.
Dirt in the jets.
Steam pressure not suitable for the suction lift.
Injector casing not airtight.
Jet or tube joints not airtight.
Steam jet lost out.
Gravity ring valve on delivery jet not open.
Injector not adapted to conditions.

Suction Line

No water.
Bottom of pipe not submerged.
Pipe clogged.
If hose, the lining may have curled in or hose may be kinked or flattened.
Water too hot.
Foot valve stuck.
Strainer clogged.
Supply-valve disc loose.
Supply-valve not open.
Suction line has large air leak in joints etc.
Supply valve throttled too much.
Pipe screws too far into valve.
Suction lift too great for the steam pressure.
Suction line too long or has too many turns so that equivalent suction lift is too great. Use oversize pipe for deep suction lifts.
Pipe cracked or pitted.
Pipe scaled up.
Suction pipe ends may have large burrs which throttle the water.
Some cheap valves do not have full flow area.
Water surface must be open to atmosphere.
Valve packing is important—keep it drawn down airtight.

Overflow

Choked with too small a pipe.
Overflow valve not opening up wide.
Exhaust restricted in some way.

Condition—Overflow Discharging Water at Temperature Well Below Boiling Point, But Injector Not Forcing Water.

Injector

Dirt in delivery jet parallel bore or spill holes.
Injector jets worn out.
Jets limed up.
Overflow valve not airtight.
Delivery jet ring valve not working.
Injector not adapted to conditions.

Steam Line

Line choked somewhere.
Line pipe too small.
Steam-valve opening too small or small valve opening.
Steam pipe supplies other apparatus? Injector line should be direct special line.
Steam valve not opened wide.
Boiler flooded with water.
Is boiler large enough to hold steam pressure?
Steam pressure not high enough for conditions.
Pipe screws too far into steam valve.
Pipe ends burred in till area is reduced excessively.
Steam-valve disc loose.
Steam-valve steam thread stripped.

Suction Line

Water-supply valve not throttled properly.
Small air leak.
See that injector nut does not interfere against body, etc., until it has clamped tail pipe tightly.
On lower steam pressures the injector may need special adjustment if supply water is taken under pressure.

Delivery Line

Delivery-line boiler check stuck shut.
Boiler check installed backwards.
Stop valve closed or disc loose.
Pipe too small.
Pipe limed up.
Pipe resistance more than 125 per cent of steam pressure due to heater coils, long line, many ells, etc.
Leaky boiler check valve.
Pipe screws too far into valve.
Some cheap valves do not have full flow area.

Overflow

Overflow valve not airtight.
If very cool, there is not enough steam to force water to boiler under existing conditions.

Condition—Overflow Discharging Hot Water Mixed with Steam.

Injector

Injector not adapted to this steam pressure.

Steam Line

Steam pressure too high for conditions.

Suction Line

Air leak in suction line.
See that injector nut does not interfere against body, etc., until it has clamped tail pipe tightly.
Suction pipe partly choked.
Hose lining curled in till area of hose is throttled.
Water too hot.
Strainer partly clogged.
Foot valve partly open.
Pipe screws too far into valve.
Suction lift too great for steam pressure.
Suction line too long or has too many turns so that equivalent suction lift is too great. Use oversize pipe for deep suction lifts.
Pipe cracked or pitted.
Pipe sealed up.
Suction pipe ends may have large burrs which throttle the water.
Some cheap valves do not have full flow area.
Water surface must be open to the atmosphere.
Valve packing is important—keep it drawn down airtight.
Suction valve not open.

Overflow

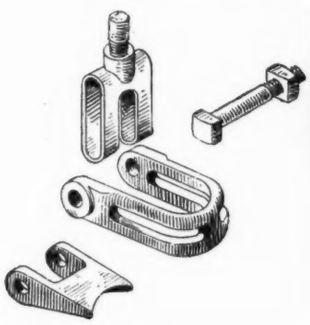
If very hot with some steam, there is not enough cool water to condense steam at that steam pressure under existing conditions.

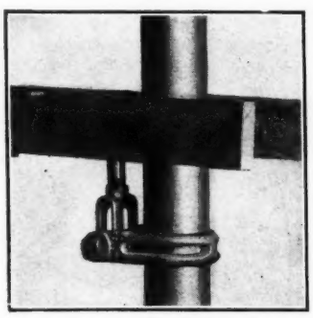
In the use of such a classified list of troubles the danger lies in the operator thinking each item is, of course, correct in his plant. For this reason it is sometimes advisable to attack the problem from the functional angle, as follows: The boiler, the steam line, the suction line, the delivery line and the injector itself.

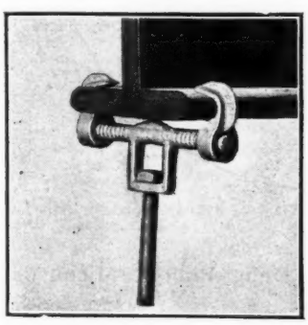
Two Helpful Devices for the Steamfitter

The firm of Heide & Resek, 46 West 43d St., Bayonne, N. J., has been formed recently for the sale of a number of patented articles intended primarily for the use of builders; two of these devices, however, are likely to prove useful to steamfitters and others having to put up piping or to make other alterations around a power plant.

The pipe hanger, shown at the top in the illustration, is designed mainly with the idea of making it easy to install. The photograph shows it in place, and the drawing shows the separate parts. The important part is the jaw, shown at the bottom in the drawing; it turns loosely on the bolt, and when the hanger is first installed its sharp curved edge is against the pipe and somewhat above the center of the bolt. When the pipe







Above, the pipe hanger as installed and as disassembled; the swivel jaw with the curved edge wedges itself against the pipe and so keeps it from slipping.

Left, the beam clamp, which may readily be applied to different sizes of beams.

begins to slip downward, the jaw catches and bites into it, thereby wedging itself in between the bolt and the pipe and holding the latter securely.

The same principle is used in a number of similar fittings, each of which is designed to meet some particular problem in the fastening of pipes, and all of which are made so as not only to be installed easily, but also to be removed with the least possible damage to the building.

The same idea is carried out also in another device, the adjustable beam clamp, which is shown at the bottom in the illustration. It is made in three models, light, medium and heavy, but each one is designed to fit any ordinary size of beam. The holes in the two jaws have an oval cross-section, the longer axis being vertical. In each side of the holes, central with the horizontal axis, there are grooves that engage with the teeth shown on the connecting rod. When this rod is turned so that the bolt is parallel with the beam, therefore, the jaws may be moved along the rod readily, since the teeth are not in engagement with the grooves. When installing the device, the jaws are pushed up against the beam, and when the connecting rod is turned to the position shown in the illustration, the jaws are held in place by the teeth on the rod.

Operating an Absorption System

A constant steam pressure should be maintained upon the generator of the absorption system in order to obtain capacity. When insufficient steam pressure is carried in the generator coils, two things result: First, not enough anhydrous ammonia is generated, that is, distilled off, curtailing the supply of anhydrous in liquid receiver. This allows gas to pass through the regulating valve, lowering the output. Secondly, the weak liquor remains too strong or concentrated, and upon reaching the absorber its capacity for absorbing gas is below normal, consequently the pressure at the absorber remains higher than it should be. Now, the lower the pressure in the absorber, the lower the pressure and consequently the temperature of the gas in the brine cooler or expansion coils, owing to the definite relation between the boiling point of the ammonia and its related pressures, and a low cooler pressure allows a lower brine temperature to be carried. For best results a full charge of ammonia is essential. The strength of the rich liquor should be about 27 to 28 deg. Baumé and the weak liquor 17 to 18 deg. Baumé. This gives on an average a range of about ten degrees.

When starting up in the morning the level in the generator will drop somewhat, but it soon regains its regular level. Any serious drop indicates a boil-over, which will require the anhydrous receiver and cooler expansion coils to be purged to restore normal working conditions. By allowing heat to enter the steam coils gradually, no trouble from this source will occur. The proper level of the solution in the generator should be maintained by charging anhydrous ammonia only.

Aqua ammonia is much harder on packing than anhydrous. In the average plant the ammonia rod must be renewed two or three times a year. This rod is made from crucible steel, well polished, etc., but it wears fast, for practically an etching process on the rod is going on all the time, and repacking is a very frequent occurrence. A rod made from high-quality drill rod, annealed only at the ends sufficiently for machining, then put on centers and ground and polished true, will also give two years' wear or more and save its cost twice over in packing. An oil cup placed above the rod and ammonia oil dropped on the rod constantly will also double the life of the packing. Three drops a minute is sufficient. Always tighten up the stuffing box slightly after shutting the pump down for the night, and always loosen the stuffing box the same amount when starting up. This saves the packing from injury, gives it a longer life and prevents injury to piston rod. The speed of the ammonia pump should be adjusted so as to handle from 0.5 to 0.6 gal. of aqua per minute per ton of refrigeration.

Occasionally, the ammonia pump becomes gasbound owing to trying to handle an over-rich or supersaturated mixture; that is, a mixture in which there is more ammonia than the water will hold under the existing pressure and temperature conditions. This is worse during warm weather when the aqua receiver absorbs heat from the hot engine room. The pump will run jerkily, which may be corrected by opening the relief valve on top of discharge chamber of the pump. This relieves the gas to the aqua receiver and, if the pump is operated very slowly, will effectively relieve the gasbinding. The ammonia pump should be operated very slowly and as steadily as possible to take advantage of the exchanging effect in the exchanger.

Steam Engine Is the Favorite Prime Mover in Massachusetts Industries

Prime Movers of 1,200,000 Hp. Drive These Mills, Assisted by 700,000 Hp. of Motors Using Purchased Power

THE 1920 survey made by *Power* and the *Electrical World* is based on information furnished by 941 mills and factories in response to approximately 2,800 questionnaires representing all concerns employing over fifty men. The Census of Manufacturers for 1919 indicates a total of 11,906 mills and factories of all sizes. These returns have been grouped into fifteen general industries. From the standpoint of total horsepower of all kinds installed, the textile industry comes first, with 860,000 hp. in round numbers, followed by paper and printing, 225,000 hp., and iron and steel products, 207,000 hp.

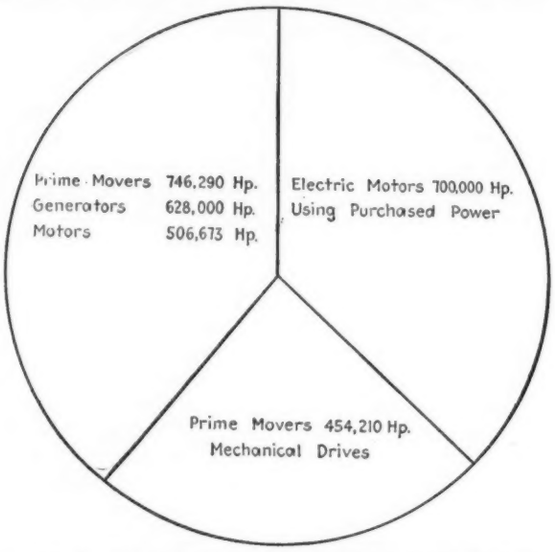


FIG. 1. PRIVATE DRIVES EXCEED PURCHASED POWER DRIVES

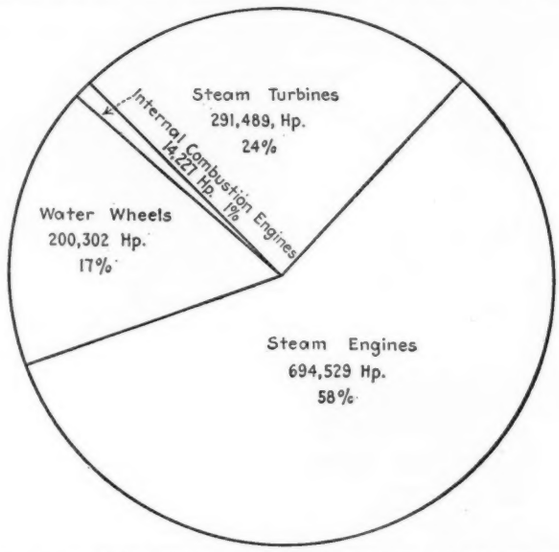


FIG. 2. STEAM ENGINES PREDOMINATE IN INDUSTRIAL PLANTS

Approximately one-third of the total prime-mover power is delivered through mechanical drive, and two-thirds furnish electrical power. Over one-half of the prime movers are steam engines, one-sixth waterwheels and one-fourth steam turbines. The average size of engine is 275 hp., average waterwheel 180 hp., and steam turbine 875 hp. About 1¼ per cent of prime movers are internal-combustion engines.

It can be seen in Table I that steam engines lead in every industry except electrical equipment and paper and printing. In the first, steam turbines lead, pulling 80 per cent of the load. Waterwheels are most used, relatively, in the paper industry, furnishing power equal to that of steam engines.

This survey has extended over two years. Returns are now being made up for Ohio, Illinois, Michigan and New Jersey.

Table II indicates that alternating-current generators predominate over direct-current units, ten to one, by capacity.

Of consumed electrical energy 39 per cent was generated in private plants, representing 633,435,000 kw.-hr., against 973,670,000 kw.-hr. of purchased power, in 1920. The textile industry leads in consumption of power, as it required 40 per cent of the total.

Massachusetts ranks fifth as an industrial state, according to the Census of Manufacturers of 1919, with a capital investment of $2,964,177,000 and manufac-

TABLE I—TOTAL PRIME MOVER EQUIPMENT, AND SUMMATION INCLUDING MOTORS USING PURCHASED POWER

Industry	Total Power Including Prime Movers and Motors Using Purchased Power	Steam Engines		Steam Turbines		Internal Combustion Engines		Waterwheels	
		No.	Hp.	No.	Hp.	No.	Hp.	No.	Hp.
Chemicals	28,043	65	9,060	16	3,225	20	392	3	186
Electrical equipment and machinery	38,088	8	3,925	6	24,718	1	75	2	180
Food and kindred products	64,030	104	25,902	5	1,718	11	1,047	17	2,063
Iron and steel and their products	207,443	264	62,924	37	10,840	10	2,324	59	6,755
Leather and its products	97,502	165	33,183	3	9,200	2	268	5	551
Lumber and its products	58,332	231	32,772	2	318	9	1,726	79	5,780
Metals and metal products other than iron and steel	42,474	39	10,084	2	260	5	403	8	727
Paper and printing	226,399	157	63,794	28	29,600	3	377	155	62,228
Railroad repair shops	15,159	12	7,753	8	1,000	1	6	.....	.....
Shipbuilding	2,304	2	653	.....	.....	2	251	.....	.....
Stone, clay and glass	40,000	78	13,186	5	5,853	7	431	4	780
Textiles	861,548	1,033	371,092	154	177,513	17	5,453	649	104,290
Vehicles for land transportation	12,805	13	2,417	1	275	2	235	4	408
Miscellaneous	124,696	266	41,677	35	15,329	6	1,181	107	15,408
Rubber	81,644	82	16,107	31	11,640	1	57	9	940
Totals for all industries of Massachusetts	1,900,467	2,519	694,529	333	291,489	97	14,227	1,101	200,302

tured products valued at $4,007,452,000. Motor drives are 72 per cent belt-driven, 22 per cent direct-connected and 6 per cent chain-driven. One-third of the total number are in textile mills. Favorite voltages are 220-volt direct current, 35 per cent of total. Alternating current voltages of 220 and 550 are equally divided in two-thirds of the alternating-current motors.

Table II is for the 941 companies sending returns. All other tables are estimated so as to represent the total of 11,906 concerns.

While 64,534 motors aggregating 699,920 hp. operate on purchased energy, 52,504 motors of 506,673 hp. use power generated in private plants, these figures representing all plants in Massachusetts. There are 58,127 motors of less than 5 hp. each. The methods of driving are: Belt, 83,685; chain, 6,393; direct-connected, 25,660. Direct-current voltages of 220,550 and 110 predominated, while alternating-current voltages were 220 and 550, 440 and 120 in order, according to reports received. Reports from 442 companies on the use of starting switches for motors, show snap switches installed by 134, knife switches and safety switches 359, auto starters 245, magnetic switches 103, remote control 74, and circuit breakers 231. The same number of concerns report that 60-cycle current is used by 367 companies as three-phase, by 35 two-phase and by 13 single-phase. One concern uses 50-cycle two-phase, and 6 use 40-cycle three-phase.

Fuses for motor protection were reported by 269 companies; 173 use the standard type fuse, consuming 10,159 per month and 0.504 per motor per month. Refillable or renewable fuses are used by 158 companies, amounting to 4,367 re-fills per month and 0.472 per motor.

TABLE II—SEGREGATION OF THE INDUSTRIAL LOAD OF 941 COMPANIES OF MASSACHUSETTS

Industry	Companies Reporting		Electric Generators—Direct Current		Electric Generators—Alternating Current		Electrical Energy Consumed		Motors Installed		Distribution of Drives		
	Total Number	Number Using Electrical Energy	Number	Total Rating, Kw.	Number	Total Rating, Kw.	Privately Generated, Kw.-hr.	Purchased, Kw.-hr.	Number	Total Rating, Hp.	Number Under 5 Hp.	Belt	Chain	Direct or Geared
Chemicals	34	22	16	1,170	7	2,256	4,772,350	16,648,079	1,624	16,423	682	1,226	91	307
Electrical equipment and machinery	20	10	3	995	4	13,500	22,021,313	3,386,960	9,173	28,832	7,414	6,726	87	2,360
Food and kindred products	22	12	11	1,100	5	5,930	8,687,200	4,438,848	1,473	12,099	493	1,245	33	195
Iron and steel and their products	228	161	55	5,739	54	11,061	20,512,709	64,045,025	8,478	102,564	2,376	6,530	248	1,700
Leather and its products	63	45	21	2,007	11	9,195	12,258,705	7,243,746	3,215	17,933	1,982	2,990	93	132
Lumber and its products	61	27	5	288	7	1,154	2,357,176	2,977,714	513	4,689	164	451	3	59
Metals and metal products other than iron and steel	28	18	7	367	1	450	803,000	1,869,047	282	4,965	111	264	5	13
Paper and printing	63	47	31	2,691	52	36,691	118,024,232	31,582,420	3,141	50,734	1,344	2,630	71	440
Railroad repair shops	1	1	0	0	3	1,200	4,070,000	0	213	5,000	31	72	4	137
Stone, clay and glass	17	9	0	0	8	4,225	4,210,615	2,008,410	523	4,137	243	252	179	92
Textiles	336	229	90	5,331	134	100,025	139,123,213	113,958,695	13,547	165,093	6,440	8,400	1,324	3,823
Vehicles for land transportation	3	3	0	0	0	0	0	3,009,120	110	1,716	66	98	0	12
Miscellaneous	45	29	8	768	8	1,747	2,415,670	5,755,519	916	10,718	366	634	50	232
Rubber	20	14	9	539	11	7,735	13,256,358	60,880,461	2,605	39,740	684	1,242	135	1,228
Totals for all industries of Mass.	941	627	256	20,995	305	195,169	352,512,541	317,804,044	45,813	464,643	22,396	32,754	2,319	10,730

TABLE III—ELECTRICAL ENERGY GENERATED AND PURCHASED IN MASSACHUSETTS

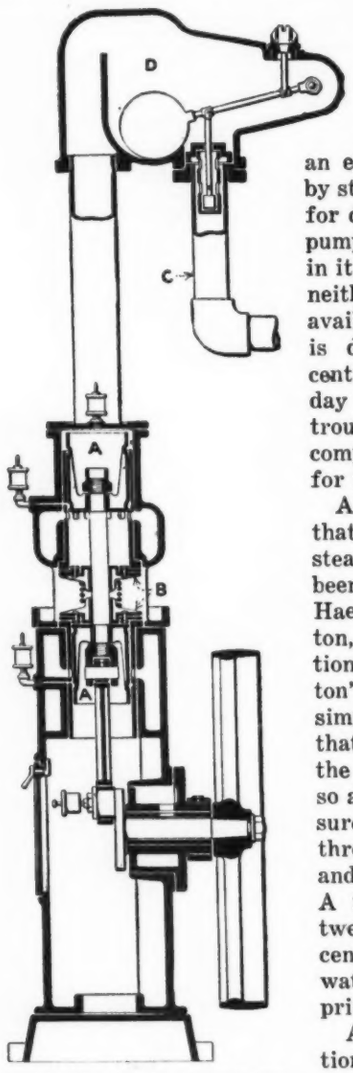
Industry	Electric Generators—Direct-Current		Electric Generators—Alternating Current		Electrical Energy Consumed		
	No.	Total Rating, Kw.	No.	Total Rating, Kw.	Generated Private Plants, Kw.-hr.	Purchased from Public Utilities, Kw.-hr.	Total Energy Consumed
Chemicals	21	1,496	9	2,880	6,110,000	19,800,000	25,910,000
Electrical equipment and machinery	7	2,330	9	31,600	51,500,000	8,100,000	59,600,000
Food and kindred products	12	1,178	5	5,930	9,130,000	36,200,000	45,510,000
Iron and steel and their products	73	7,630	72	14,700	27,340,000	103,000,000	130,340,000
Leather and its products	27	2,530	14	11,650	15,500,000	59,250,000	74,750,000
Lumber and its products	11	628	15	2,520	5,125,000	20,200,000	25,325,000
Metals and metal products other than iron and steel	52	4,450	86	61,000	1,330,000	16,700,000	18,030,000
Paper and printing	32	2,740	53	37,350	120,000,000	207,000,000	327,000,000
Railroad repair shops	.....	.....	4	1,490	5,060,000	5,210,000	10,270,000
Shipbuilding	.....	.....	.....	.....	0	1,310,000	1,310,000
Stone, clay and glass	.....	.....	8	4,225	4,210,000	29,900,000	34,110,000
Textiles	223	13,220	332	248,000	345,500,000	312,000,000	657,500,000
Vehicles for land transportation	3	258	1	138	1,350,000	16,500,000	17,850,000
Miscellaneous	9	845	9	1,920	26,600,000	38,900,000	65,500,000
Rubber	10	588	12	8,440	14,500,000	98,600,000	113,100,000
Totals for all industries of Massachusetts	480	37,893	629	431,843	633,435,000	972,670,000	1,606,105,000

TABLE IV—ESTIMATE OF POWER EQUIPMENT

Industry	Steam Engines		Steam Turbines		Internal Combustion Engines		Waterwheels	
	No.	Hp.	No.	Hp.	No.	Hp.	No.	Hp.
Chemicals	25	3,477	2	400	4	80	3	186
Electrical equipment and machinery	8	3,925	6	24,718	.....	.....	.....	.....
Food and kindred products	19	4,745	2	700	.....	.....	.....	.....
Iron and steel and their products	92	21,850	8	6,330	3	727	33	3,860
Leather and its products	47	9,430	3	9,200	.....	.....	4	527
Lumber and its products	48	7,560	1	31	.....	.....	7	535
Metals and metal products other than iron and steel	23	5,940	.....	.....	.....	.....	7	615
Paper and printing	96	38,700	40	29,600	.....	.....	99	39,600
Railroad repair shops	4	2,240	.....	.....	.....	.....	.....	.....
Shipbuilding	.....	.....	.....	.....	.....	.....	.....	.....
Stone, clay and glass	4	675	4	2,800	.....	.....	3	615
Textile	638	229,300	143	165,200	29	4,175	546	87,760
Vehicles for land transportation	1	57	1	134	1	16	.....	.....
Miscellaneous	71	11,230	19	8,440	5	955	29	4,130
Rubber	21	4,130	36	11,640	.....	.....	2	117
Totals for all industries of Massachusetts	1,097	343,259	265	259,193	42	5,953	733	137,885

Hazleton Centrifugal-Pump Primer Exhausts Air from Pump

Frequently, when a centrifugal pump is installed above the level of its water supply, it must be primed, or filled with water, before it will operate. There are various ways of doing this, perhaps the most common being to install a check valve or foot valve at the lower end of the suction pipe, so that the pump may be filled with water by any convenient means, as, for instance, by connection with the city water supply. Another common method, which does not require a foot valve, is to use an ejector, operated either by steam or compressed air, for drawing water into the pump by exhausting the air in it. Sometimes, however, neither steam nor air is available, and sometimes it is desired to start up a centrifugal pump on a Sunday without going to the trouble of starting a large compressor to obtain air for priming the pump.



SECTION OF THE PRIMER
The air pump exhausts the air in the centrifugal pump (not shown), but when water comes it is stopped in D.

A pump-priming device that is independent of steam and air supply has been devised by Barrett, Haentjens & Co., of Hazleton, Pa., as a natural addition to their line of "Hazleton" pumps. It consists simply of a piston air pump that draws the air out of the centrifugal pump and so allows atmospheric pressure to force water up through the suction pipe and into the pump casing. A float-operated valve between the primer and the centrifugal pump prevents water from entering the primer.

As shown in the illustration, the priming pump has two pistons, *AA*. Air-inlet valves are eliminated, as the air enters the cylinders through ports that are uncovered by the pistons at the end of their stroke. The leather-faced discharge valves *B* slide on the piston rod and, being of large area, require only a slight movement for opening and so tend to have a long life. The connecting rod, crank, etc., are inclosed, but may be reached by removing the cover shown in one side of the crankcase.

The suction pipe *C* of the pump primer is connected through a water trap and vacuum breaker *D* to the top of the casing of the centrifugal pump. As soon as enough air has been drawn out of the pump casing through this pipe, atmospheric pressure forces the water up into the suction pipe of the centrifugal pump, into the pump casing, and then into the pipe *C*. To prevent the water from following through into the primer the stop valve *D* is arranged so that when water enters it the float rises and opens the air-inlet valve at the top, thus admitting air and tending to allow the water to flow back in pipe *C;* but as soon as the water level in *D* falls, the air valve is closed and the water is drawn in again, so that after a few fluctuations the float and the air valve remain in such a position that just enough air will be admitted to maintain a constant level of water in *D*. The centrifugal pump, of course, is then primed and is ready for operation. As soon as it is started, the pressure quickly rises in pipe *C*, thus raising the water level and the float in *D* high enough to open wide the air-inlet valve and to close the other valve, thus preventing water from passing into the primer.

One of the advantages claimed for the device is that it handles air only, and not water; this obviates trouble with bad water, such as found in mining service, for which the primer was originally designed. It can be driven by a small electric motor mounted on the same base, and so, as stated previously, is independent of any steam or air supply, but still has the advantage of a steam or air ejector in that it requires no foot valve in the centrifugal-pump suction pipe.

The primer may be arranged so as to serve several centrifugal pumps, but the connecting piping must be so installed that it can be completely drained, as otherwise water that would remain in it would be drawn into the float chamber *D* upon starting up the primer.

If, under exceptional conditions, the centrifugal pump gives trouble with air binding while it is in operation, the air can be removed continuously by keeping the primer in operation. If such operation is required, the connection of pipe *C* to the top of the centrifugal-pump casing would be insufficient, and connection would have to be made to the suction pipe of the pump at the point where it enters the casing.

New Opposed-Piston Diesel for Stationary Plants

The Fullagar opposed-piston Diesel engine has been used in England for marine purposes. The latest step taken is the designing of this engine for stationary plants. The one unit so far built in England is a four-cylinder machine, the connecting rods of two cylinders being coupled to a single crank.

The peculiar advantage in the opposed-piston design lies in the development of large powers in engines having reasonable crank throws. The engine in question has a 14-in. bore and each piston has a 16-in. stroke; the combined piston travel in each cylinder is then 32 in. This gives a 14 x 32-in. cylinder with a 16-in. crank throw.

The engine occupies less floor space than does a standard Diesel of like power. The Fullagar engine is higher, but actually requires less headroom, since the connecting rod need not be lifted above the top of the engine. The builders claim that a 1,125-hp. engine will take less room than a 500-hp. standard Diesel.

It would seem that in large units the opposed-piston Diesel should find a large field of usefulness. With the usual design the piston stroke determines the crank throw, which in turn largely influences the proportion of the other parts. It is reported that this opposed-piston engine will soon be built for stationary work by an American manufacturer.

EDITORIALS

Knows Enough To Ask Questions

IN DISCUSSING a certain industry recently, one of the Government specialists, who has for years studied the problems of that industry, remarked, "Men in that field now know enough to ask intelligent questions." This is a splendid indication of progress within that particular field, and from it individuals, as well as other industries, may well take profit.

The most characteristic feature of the ignorant person is his unwillingness to exhibit a lack of knowledge. Such a person always reminds one of the old adage, "He who knows not and knows not that he knows not, is a fool; pity him."

The problems of a power plant, though based upon simple principles of science and engineering, become in modern practice extremely complicated as to detail. It is not alone the apprentice who finds in every-day affairs complex and difficult questions. The wisest and most experienced engineer, when he gets a little out of the field in which his principal interest has been, will find new problems and will need new information.

It is a sign of wisdom to ask intelligent questions. It is a sign of folly to be unwilling to ask. Moreover, it is a sign of real ability to answer questions clearly and accurately, even though the question may seem quite simple.

It should be a part of our every-day responsibility to answer cordially such questions as come to us, even those that may seem foolish at first thought. By good-natured and patient co-operation with the younger and less-experienced members of the staff, the older ones can command not only their respect for greater knowledge, but their loyal aid and helpfulness as well. These things will do a great deal to make the plant force work more happily, and perhaps may even make the plant work more efficiently. Both the asker and the answerer will be gainers if the question and answer be rightly framed.

Heat Insulation Deserves Careful Study

IF THERE was any science of heat insulation twenty years ago, the fact was certainly unknown to the general run of operating engineers. In fact, the very name "heat insulation" was unknown to most practical men at that time. The term "pipe covering," then exclusively used and still widely used for the sake of simplicity, was an adequate description of what was desired. If the pipes were covered, the engineer was satisfied. The material used, the thickness and the method of application received scant attention.

This condition has now definitely changed, particularly in the larger power plants where the selection of equipment and accessories is generally determined by a scientific investigation of the facts. The same methods are followed in some of the smaller plants, but there is still much room for improvement.

The scientific facts in regard to the savings obtainable from heat insulation have been well established in recent years and are now available in a form that any engineer can understand and use. The choice of the kind of insulation to be used hinges primarily on the question of efficiency, but it is important to remember that the efficiency of the new covering is not the whole story. It is essential that this efficiency be maintained for a long period. Perhaps the best way to settle this question is to study the experience of other plants and particularly to note the specifications used in the new plants whose layouts give evidence of expert engineering work.

The most economical thickness to use depends on the steam temperature, cost of coal, pipe size and the percentage of time that the piping is under steam. The ideal thickness is that which leaves the maximum net saving after subtracting the interest and depreciation on the investment from the total value of the fuel saved. Tables are obtainable that show the most economical thicknesses for various conditions. The minimum thickness commercially available is ordinarily about one inch. This is often called "standard" which has doubtless had something to do with the fact that it is so widely used under circumstances where thicker covering would be a much better investment. With the present price of coal "standard-thick" covering is usually too thin, except for low-pressure lines or very small piping. Even for such lines it sometimes pays to use thicker covering. As the steam pressure increases or the pipe size goes up, the most economical thickness continually increases, giving the greatest thickness for large drums and flat surfaces.

The method of application is best determined by consultation with those who have had long experience in this field. Aside from making a neat-appearing job, free from cracks which cause losses by air circulation, the main idea is to put the covering on *to stay*. For the highest type of job it often pays to finish by sewing on a jacket of heavy duck. In most cases the cost of painting the canvas is well worth while, on account of increased life and more shipshape appearance.

The science and art of heat insulation are now well advanced. First-class insulating materials are available, and there is no difficulty in obtaining reliable information as to proper thicknesses and methods of application. It only remains for engineers in general to take full advantage of this state of affairs.

Efficiency in Power Developments at Niagara Falls

HYDRAULIC turbines have been developed to a remarkably high efficiency, reaching ninety-four per cent in some of the larger types of units. These machines are capable of developing ninety per cent efficiency from half load to full load. Remarkable as these results are, the large electric generator can do even better by crowding well up to the ninety-eight per cent mark. As a result it is possible to deliver at the bus-

bars as high as ninety per cent of the total energy in the water from the forebay to the tailrace.

Although high efficiency in turbines and generators is important, the over-all efficiency in the development of a water-power site is of equal importance. In many of the more modern water-power developments the over-all efficiency has been fairly high, whereas in many of the earlier developments the efficiency was very low. This is particularly true where small industries have grown up around a water-power site and each has developed small amounts of power sufficient at the time to meet its needs.

Probably nowhere else in the world has the progress in water-power development been exemplified in the efficiency of development as at Niagara Falls. Each cubic-foot-second of water that flows from Lake Erie to Lake Ontario is theoretically capable of developing slightly over thirty-seven horsepower. The first important installation at Niagara Falls utilized only about one hundred and forty feet of the total head and developed eleven horsepower per cubic-foot-second, which is equivalent to thirty per cent of the total energy due to the head between the two lakes. Since that time different developments have increased this efficiency until in 1919 it reached about sixty per cent under a two hundred and fifteen foot head, which is about the highest that it is possible to obtain in plants located immediately at the Falls.

In this issue the leading article describes the general engineering features of the Queenston-Chippawa development of the Hydro-Electric Power Commission of Ontario. In this development eighty-one per cent of the total energy in the water due to the fall between the two lakes is delivered at the busbars of the plant. This is probably as efficient as it will ever be possible to use the head between the two lakes for power development. In this project three hundred and fifteen of the total three hundred and twenty-seven feet head is used, ten feet of which is lost in the intake works, canal and penstocks, leaving an effective head of three hundred and five feet on the turbine. As this works out, about ninety per cent of the energy in the water delivered to the turbine is available in the form of electric power on the busbars of the plant.

A study of an over-all development to be made by digging a canal across the Niagara peninsula showed that, although the total fall between the two lakes would be utilized in the system, the most economical head on the turbines would be less than three hundred feet. In the latter the canal would have been twenty-four miles long and the penstocks one mile; in the Queenston-Chippawa development the canal is only thirteen miles long and the penstock four hundred and fifty feet.

Fortunately, conditions are favorable for developing Niagara's power under a head of over three hundred feet on both sides of the river, and undoubtedly in no distant future a similar project to that carried to successful completion by our Canadian neighbors will be under way on the American side. The Queenston-Chippawa development is of such large proportions and the engineering details have been worked out with such thoroughness as to leave no doubt as to what the outcome of such a development will be. Although the initial installation of two hundred and seventy-five thousand horsepower will not be completed before the end of the year, the results so far are sufficient to assure that the judgment of the engineers responsible for this undertaking was well founded.

Modernizing the Steam Engine

MANY engineers labor under the impression that by the addition of a second cylinder the power of an engine is increased. In fact, as is pointed out in the discussion on the compound engine on page 1015, the same power may be obtained by expansion in a cylinder having a volume equal to that of the low-pressure cylinder as can be obtained from the compound engine. Compounding has been resorted to in an effort to eliminate most of the cylinder condensation occurring when the entire expansion takes place in one cylinder.

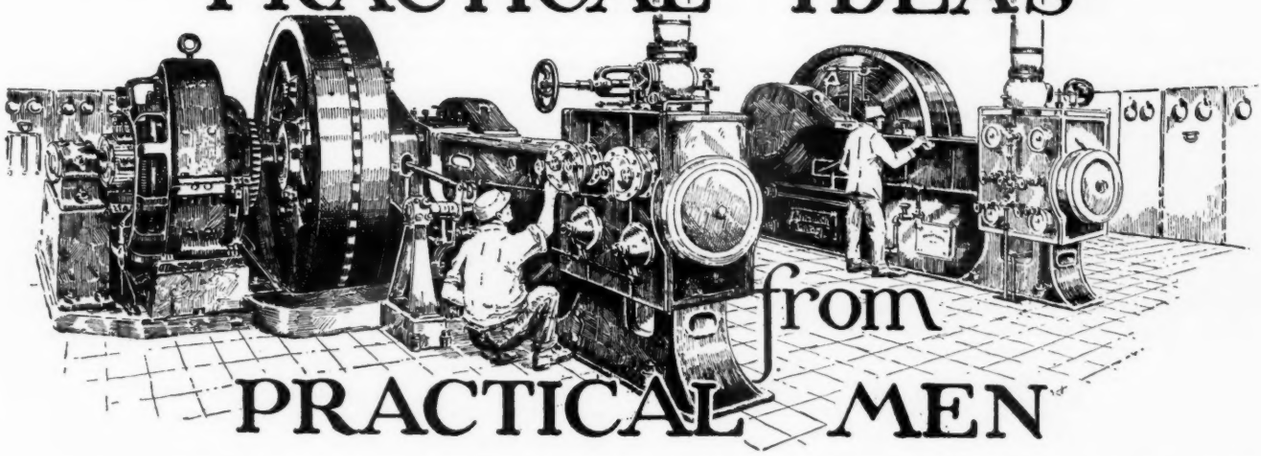
If the initial condensation can be eliminated by avoiding the interchange of heat between the cylinder walls and steam, then the necessity of compounding disappears. Before the advent of the unaflow engine efficiency was obtained only by a multiplicity of cylinders, the number running as high as four in a triple-expansion engine. The unaflow experiences but little heat interchange between the walls and steam. As a consequence the expansion is nearly adiabatic, and a single-cylinder unit has an efficiency as high as if not higher than the triple-expansion unit. This fact at once allows the engine mechanism to be simplified and by the elimination of one or more cylinders and frames reduces the cost per horsepower. As a further advantage the foundation is cut in half and the room space reduced proportionally.

There are in daily operation thousands of steam engines of all sizes and types that are operating inefficiently. Most of these inefficient engines could be rebuilt into more economical units by replacing the present cylinder by a unaflow cylinder and valve rigging. The advantage to be gained by such remodeling of old engines is obvious. The total cost of an installation consists of much more than the price of the engine. By replacing the cylinder, even though this work costs seventy-five per cent of the original price of the engine, the investment in a new foundation, new generator, piping, etc., is avoided. The increased efficiency should be such that the cost of replacement would be returned in a few months.

One often feels like complaining at the high-sounding names the chemists have given to many familiar substances. Then one turns to inspect the efforts of laymen at this naming business and finds there another type of genius—that for giving something several different names, none of which means much. As a prize example take the substance the chemist calls *sodium carbonate*. The housewife insists that it is *sal soda* or *washing soda*. Her husband, according to his particular job and inclinations may call it by any of the aforementioned names or any of the following: *Soda ash, soda crystals, Alkali, Scotch soda, crystal carbonate of soda, concentrated crystal soda, black ash* or just plain *soda*. None of these should be mistaken for the stuff that is sold at the thirst-quenching "fountains."

Commenting upon the recent tieup of the Interborough Rapid Transit in New York, a reporter for one of the dailies ascribes the short-circuit in the generator to poor coal. A little far-fetched, to be sure, but why criticize the reporter for becoming slightly mixed, when the mayor of that city discourses on how he would furnish unlimited power for heat and light to its six million population by utilizing surplus waters of the Barge Canal and by harnessing the tides of the lower bay?

PRACTICAL IDEAS from PRACTICAL MEN



Fitting of Keys Causes Loose Pulleys

I have noticed in a number of cases where well-fitted solid hub pulleys have worked loose on lineshafting, and find that the real cause of the trouble is not poor fitting of the pulleys on the shaft, but is in most cases caused by the key not being fitted properly.

The usual cause of a pulley becoming loose on a shaft is the clearance that exists between the top of the key and the bottom of the keyway in the pulley. When keys are fitted in this manner, there is nothing to bind the pulley to the shaft, and if it becomes loose and the bore enlarged it is practically impossible for setscrews to hold it tight. My method of installing pulleys on shafting is to fit the key as high as possible without danger of cracking the hub when driving the pulley over the key. This of course applies to keyways that are fitted with parallel or Woodruff keys which are set in place on the shaft and the pulleys slipped over them. In some cases, if the key is not too badly worn, shims can be placed under it to raise it high enough to bind the pulley to the shaft. I have seen a number of loose pulleys tightened in this way that have given good service. It is no small task to remove a pulley and replace it with one of smaller bore when there are a number of pulleys on the same shaft and it is needed for a 24-hour service.

LEONARD WENDT.

Grandfield, Okla.

Super-Accuracy

It is the practice of a large utilities company whose installed capacity probably is over 300,000 kw. to conduct tests on their boilers, turbines, etc., to determine the quality of coal, rating, efficiency and any other item that may be wanted. They take considerable pride in the accuracy of their results, going into many refinements to obtain this result. They follow the A. S. M. E. Boiler Code in great detail. They compute their final results to four and even six figures, as in determining the factor of evaporation, when the observed data are under no circumstances correct to more than three figures. I will cite several examples:

Take the computation of the factor of evaporation. Gages are used for the steam pressure with the smallest division about ½ in. wide and equivalent to 2 lb. gage. It is the practice to have the observer read or estimate to the fourth figure as 206.7 lb. gage. My contention is that the gage cannot be read that close for two reasons: First, in almost all cases I have observed that the needle vibrates or chatters over about 5 or 6 lb. of the scale. It requires a very accurate observer to estimate this to within even one-half a division, or 1 lb. Secondly, in order to stop the chattering the gate valve is throttled down. This necessitates almost closing the valve. Instead of correcting the evil, it increases it, for the gage will now read at least 2 lb. low. This has been proved by experiment and is readily understood.

Now, in computing the pressure the hourly averages (taken every 10 min.) are averaged for the 24-hour run and the result given to four figures, as 207.3 lb. I contend that this degree of accuracy is not justified under the foregoing conditions. Of course the gage is calibrated regularly and the water head taken into consideration. But this is not all the refinement occurring in the computation of the factor of evaporation.

The total temperature of the steam is measured by a thermocouple. The temperature is read to the nearest degree, one division being about ½ in. for each 2 degrees. The final average is computed to four figures or the nearest tenth of a degree. From the temperature of saturated steam at the pressure given and the temperature of the steam we get the degree of superheat. Marks and Davis tables are used, interpolating between values. The degree superheat is claimed or at least used to one-tenth of a degree. On one test the steam temperature was checked by a mercury thermometer corrected for 3 in. steam exposure of mercury column, and it was found that the thermocouple was reading from 3 to 4 degrees low. No cognizance of this fact was taken in the computation of results. The factor of evaporation is now computed to six figures when it has been shown that the numerator cannot be better than three figures and the denominator 970.4 is certainly not correct to more than four figures, therefore the answer cannot be better than three figures.

Another unnecessary refinement is the reading of draft gages to the nearest 0.001 in. of water. Aside from all mechanical restrictions on the accuracy, the draft oftentimes fluctuates over 0.03 or 0.04 in. of water while a reading is being attempted.

There are many others, but I think these are sufficient to justify the position I take, for, by figuring results to three places it would be within the accuracy of the instruments, and would, in the end be more accurate.

Pittsburgh, Pa. A. W. FOWLER.

Strengthening Cracked Flywheel

A crack radiating from the keyway, as shown in Fig. 1, was formed in the hub of a flywheel of a Corliss engine. The wheel was made in two segments and bolted together at the hub and rim. It was strengthened by shrinking over the hub at each end a wrought-iron band 1½ in. wide and 3 in. deep. To bring them flush with the ends of the hub, it was necessary to chip one-half inch off the side of the lugs. The bands were bored to an inside diameter of 23⅛ in., or ⅛ in. less than the diameter of the hub, and were slipped into place while at a red heat.

The shaft was jacked up high enough to allow sufficient clearance between it and the journals for the

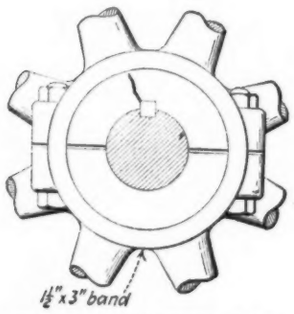


FIG. 1. CRACKED HUB, REINFORCED WITH BANDS

FIG. 2. CIRCLET OF GAS JETS FOR HEATING CRANK DISC

bands to be slipped over, and then the wheel was securely blocked and wedged and the jacks were removed. To band the end of the hub toward the crank end of the shaft, it was necessary to expand the crank disc so that it could be removed. This was done by heating the disc with a circlet of gas jets. The jets were applied by means of a number of small nozzles tapped into the inner periphery of a piece of ¾-in. pipe bent into a circle, as shown in Fig. 2.

A. J. DIXON.

St. Louis, Mo.

Silencer on Unaflow Steam Engines

An installation at the John Eichler Brewing Co., Bronx, New York City, of a silencer on the exhaust of a unaflow steam engine is of particular interest. The exhaust of this type of engine when operating noncondensing is extremely noisy. The noise is caused by the sudden exhaust that occurs due to the large area of the port. This noise is similar to that of a two-stroke-cycle gasoline or oil engine. In districts where residences are close to the power plant, this noise is disagreeable and often troublesome, as many plant operators well know.

The Eichler company first attempted to overcome the noise by leading the exhaust to a large expansion chamber. This method is frequently adopted on the assumption that the noise can be eliminated if the steam or gas is expanded down to a low pressure before being allowed to escape to the atmosphere.

It was found that adding this expansion chamber only served to alter the character of the noise, making it, if anything, a little more offensive. The expansion chamber merely served to add a resonance effect, such as is obtained when a firecracker is exploded in a barrel.

The next step was to add a Maxim industrial silencer to the outlet of the expansion tank. This outlet was 12 in. in diameter, so that it may be seen that the installation was one of considerable size.

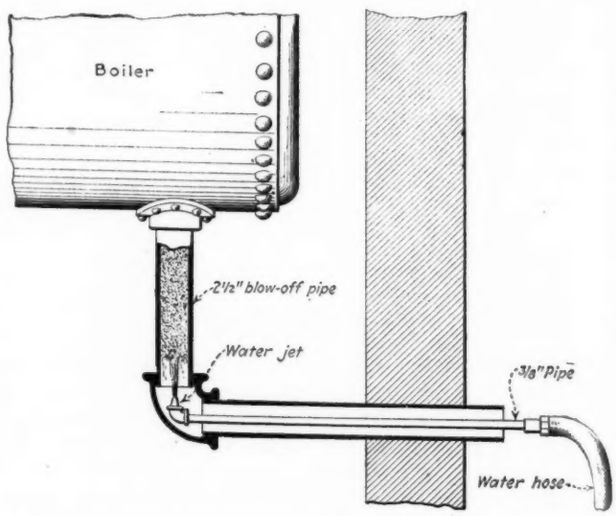
When the exhaust occurs, a noise wave is set up which spreads out in all directions. It has the velocity of sound which is approximately 1,100 ft. per second, and passes through the exhaust line, and if the latter discharges directly into the atmosphere, it is heard as the sharp exhaust noise.

When an expansion chamber is added, the noise wave merely passes through this chamber and takes up whatever resonance effect is obtained from the many reflections from the walls of the chamber. Whether or not the steam is expanded down to atmospheric pressure makes no difference. The noise wave proceeds almost independently of the medium that transmits it. It is evident from this that the noise carried by an exhaust, such as that from a unaflow steam engine, or even from an oil engine, is a wave phenomenon and the silencing of this wave cannot be accomplished by expansion of the medium that carries it. It can be silenced only by a means that dissipates the energy resident in the noise wave, a fact not usually recognized by most engineers.

Hartford, Conn. P. H. MAXIM.

Clearing Blowoff Pipe with a Water Jet

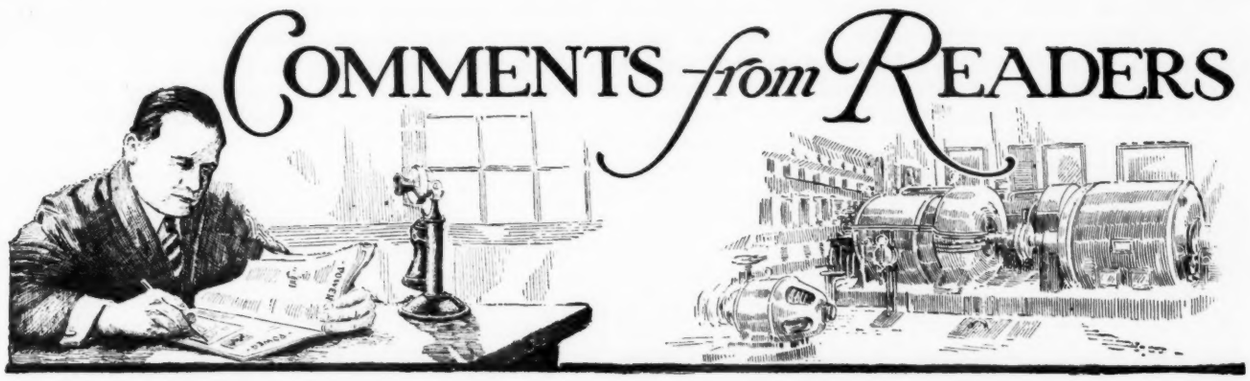
Some time ago I was confronted with the problem of a scale-plugged blowoff pipe. I knew from the nature of the scale that it was a collection of small, thin, hard flakes wedged together. At the end of the day's run I hammered the pipe with the blowoff cock open, but could not dislodge the scale. I then let the steam off the boiler and connected the city water pressure into the blowoff to force the scale upward, but without



WATER JET DISLODGED SCALE IN VERTICAL PIPE

success. With the pressure off the boiler, I removed the blowoff cock and raked the fine scale out of the horizontal pipe. I then put city water pressure on the boiler, but found that the vertical pipe held solid even with the horizontal pipe cleared, so I finally devised the scheme shown in the cut. The water jet gradually dislodged the scale and washed it out through the pipe.

Vancouver, B. C. R. MANLEY ORR.



Effects of Boiler Efficiency on Amount of Coal Burned

In the lower right-hand corner of page 725 of the May 9, 1922, issue, there is a paragraph that states that with fuel cost 70 per cent of the operating cost of a boiler plant an increase of boiler efficiency from 50 to 60 per cent results in a saving of 20 per cent of fuel, and also that an increase in boiler efficiency from 60 to 70 per cent results in a saving of 16.6 per cent of fuel. An error has evidently been made in these figures, as the fuel savings should be 16.6 per cent and 14.3 per cent respectively. With 50 per cent boiler efficiency, 20 per cent more coal is burned than with 60 per cent boiler efficiency, but the saving in raising the boiler efficiency from 50 to 60 per cent is not 20 per cent but 16.6 per cent. Likewise with 60 per cent boiler efficiency 16.6 per cent more coal is burned than at 70 per cent, but the saving in raising the boiler efficiency from 60 to 70 per cent is not 16.6 per cent but 14.3 per cent.

Schenectady, N. Y. J. DAVID WRIGHT.

Connecting Alternators in Parallel

In *Power*, May 16, Albert Banks asked what caused the circulating current between the alternating-current generators. There can be three causes for this—a difference in the wave forms of the generators, a difference in the voltages, or a phase displacement of the generators. If the machines are alike, the first cause is eliminated.

Mr. Banks states that at the time of paralleling on the 5,000-volt bus, the machines are already paralleled through the step-up transformers. These transformers insulate the terminals of one machine from the terminals of the other, so that there is not a complete electrical circuit over the neutral, through the generators, and over the high-tension bus, and no current can circulate between generators over the neutral connections. A difference in voltage, or a phase displacement of the generators, will cause a three-phase current to circulate between the generators, through the transformers and high-tension bus. For the same circulating current, owing to the impedence of the transformers, this difference in voltage will have to be larger than if the machines were paralleled through busbars. Thus the difference in the voltages of the machines may be more than is supposed.

Now, when the machines are paralleled on the 5,000-volt bus, this difference in voltage will cause current to circulate between machines through the busbars, and in addition, the difference in the phase voltages of the two machines will cause a triple-frequency current to flow through each phase of one machine, over the busbars, through the other machine and back over the neutral. This condition caused the tripping out of the circuit breakers. The 525-volt bus gives no trouble because the transformers insulate it from the generators.

If the wave forms are alike, the generators should not kick out, provided the incoming machine is exactly in phase with the 5,000-volt bus and the voltage of the incoming machine is equal to the voltage of this bus.

If the wave forms are different, the generators could still be paralleled on the 5,000-volt bus, with both neutrals connected, if one generator fed through a 5,000- to 5,000-volt delta-to-delta connected transformer bank. However, nothing is gained by so doing. The better way is to leave one generator neutral disconnected when paralleling on the 5,000-volt bus, and since the generator terminals are then connected by continuous electric conductors, grounding the neutral of one generator furnishes protection for the system.

Wichita, Kan. C. F. ROYCE.

Reconnecting an Induction Motor

In the May 23 issue of *Power*, page 831, there was a problem on reconnecting a six-pole three-phase 220-volt motor for 110 volts. The answer stated that the motor would have to be rewound. The following figures show that it may be possible to reconnect this motor six-parallel star and get good results:

The 220-volt winding is connected two-parallel delta, then the series-delta connection would give 440 volts per phase, and $440 \div 6 = 73.33$ volts per phase for a six-parallel connection. Then if the motor is connected six-parallel star, the line voltage would have to be $73.33 \times 1.73 = 127.86$ volt, which is approximately 15½ per cent too high or too many turns. If operated at 110 volts, it would be running on 86 per cent voltage, which would have the following effect:

The slip would be increased, power factor decreased and heating would be increased, but if the motor were mine, I would try the reconnection before rewinding, for the conditions under which the motors operate might be such that the difference would not be noticed or cause any ill effects. A. C. ROE.

Detroit, Mich.

[The standard alternating-current motor is designed to operate on a variation in voltage of 10 per cent plus or minus at normal frequency. When 5½ per cent is added, the condition is being approached where trouble is liable to occur, especially when it is considered that the frequency may be a little high. Furthermore, if the normal voltage of the line is 110, it will probably be less

than this at the motor terminals, so that instead of the motor having to operate on a voltage that is the equivalent of 15½ per cent low for the winding, it may be 20 per cent or more. In addition to the effect referred to by Mr. Roe, the starting torque and pull-out torque will be reduced, which may or may not be a serious item, depending on the conditions under which the motor operates. Too frequently, the cost of rewinding the motor is the only factor that is considered, when the decrease in efficiency of the motor and the loss in production due to decreased speed overshadow all other points. In many cases, if the motor was rewound, the increase in production would pay for the rewinding in a short period, let alone the improved operation that might be expected of the motor. One thing that Mr. Roe has not mentioned that might be done to improve the operation of the motor if it were reconnected, is changing the pitch of the coils. If the coils were spread nearly full pitch, it might be possible to reduce the pitch of the winding to make it suitable for a voltage within at least a 10-per cent limit of 110 volts. It will not cost very much to try reconnecting the motor, and after testing it under working conditions, if it fails to come up to standard, rewinding may be resorted to. There are so many factors entering into the problem that it would be difficult to say what the results would be; one motor's characteristic might be improved by the reconnection, while another might fall down entirely.—Editor.]

Data from Flow-Meter Charts

I noticed in a recent issue of *Power* the following question an engineer had put to his men: "Give all the data that can be obtained from a flow-meter chart."

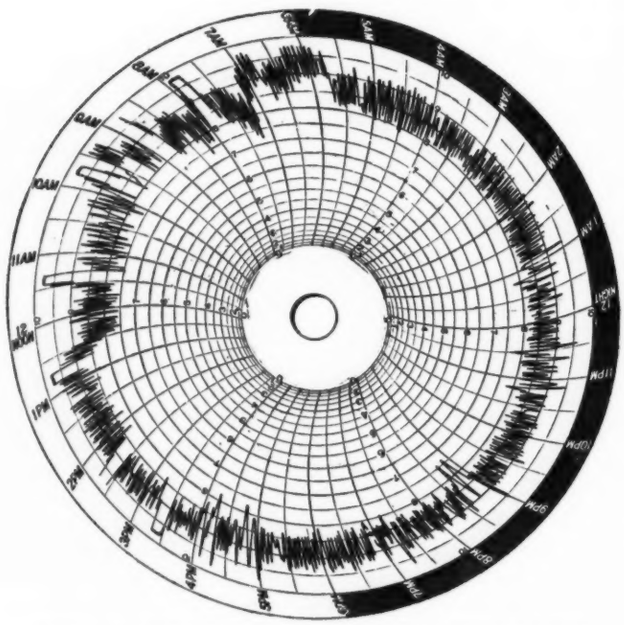


FIG. 1. FLOW-METER CHART FROM STEAM LINE OF HOISTING ENGINE

This is a good question and one that will make the men more observant and cause them to give more thought to the meters. It is a question to which all that are interested in steam power can profitably give serious thought. From my own experience the information I have obtained from flow-meter charts has been extremely valuable, not to say amazing at times.

The charts shown in Figs. 1 and 2 are from a meter installed for a test on a steam line going down a shaft of a coal mine, to supply a small hoisting engine. As the actual operating time of this hoist did not total more than a half-hour daily, it was surprising to find the chart

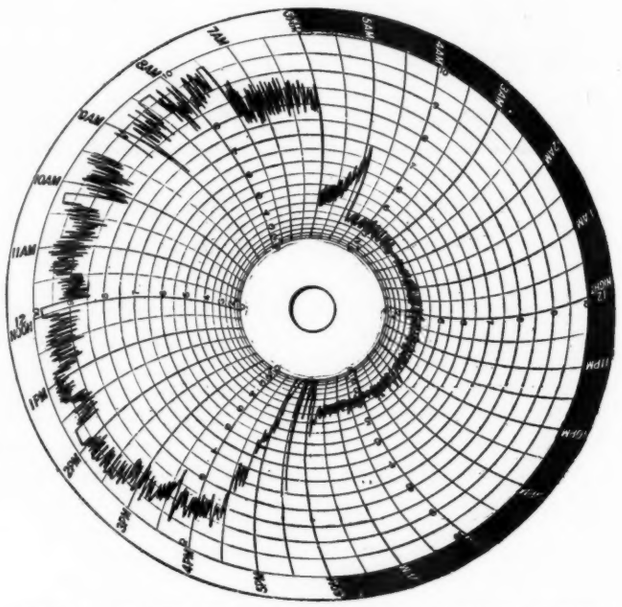


FIG. 2. SHOWS DECREASE IN STEAM CONSUMPTION AFTER CHANGES WERE MADE IN THE PIPING

from the flow meter Fig. 1 showing an average consumption of approximately 7,000 lb. of steam an hour. Investigation showed that the inside workers had connected heaters at various points and also two large sand dryers to the line supplying the engine. These extra connections were made with bare pipe and with the lines full of sags and pockets. The only way circulation could be obtained was to let the heaters blow at practically full pressure. This, of course, caused an enormous wastage in comparison to the steam actually necessary to do the heating required. After properly erecting the necessary pipes, covering and grading and providing for draining, the steam consumption was cut down, as indicated by the chart, Fig. 2. In all probability the waste would never have been discovered if the flow meter had not been installed.

A similar condition prevailed on the surface at a mine. Here the waste was plainly visible, but not appreciated until a flow meter was installed and the waste demonstrated and interpreted in dollars and cents. These cases occurred in the coal-mining region, where the idea still seems to exist that boiler coal does not cost anything, and as a result they are rather impatient on the matter of economy in the use of steam.

Some years ago a firm in Providence, R. I., purchased a flow meter and installed it in a main serving the kiers in the bleach house. Immediately upon being put in service, the meter made unusual records. The officials made a complaint to the manufacturer that the meter was not working properly. The manufacturer made an inspection which showed the meter to be working correctly, and he notified the plant officials that any irregularity must be due to plant operations. The latter, however, were dissatisfied with the meter and felt that

they had been stung. One day, while doing some engineering work for the firm, I learned of their flow meter. Upon examining some of the charts with the engineer, we noticed that the apparent irregularites occurred at fairly regular intervals and were confined entirely to the night shift. Investigation of this proved that the meter was working properly and doing its best to point out a condition that was causing the firm a large loss. The vats, which were filled with unbleached cloth by the day shift, had steam turned on them about 5:30 p.m. The regular method was to turn the steam on full to get the bleaching liquid hot and circulating through the cloth, gradually throttling the steam during the run, which lasted about thirteen hours. What was actually taking place, however, was that the night shift were keeping the steam on full blast until midnight, then shutting it off and going to sleep until morning. Of course they were very much on the job when the day shift arrived. It further developed that this method was spoiling a large amount of cloth and that the firm had been some time trying to find the cause. A little more faith in the meter would have caused someone in the plant to study the charts and find the answer himself.

These instances were all very simple, nevertheless they represent some of the unexpected services meters frequently render us, if we but study the charts.

Somewhat more interesting were the details of a meter installation on a steam main supplying steam for heating a building and the water for a swimming pool. The steam was obtained from a near-by manufacturing plant. After operating for a few months, it was decided that the meter was not working properly, as the steam bills were more than twice what it was estimated they should be. The pipe returning the condensate to the boiler plant was disconnected and the condensate weighed. This showed about half as much as the meter reading. As the conditions were nearly ideal for a meter, the causes for the meter not being correct were puzzling. Finally, the trouble was found by comparing the steam-flow record with the flow of the condensate. This developed the fact that the trap, which pumped the water back against a head of several feet, was sticking in a position that allowed live steam to blow through a vent pipe into the sewer. An interesting point about this was that a small condenser had been installed on this vent pipe some time after the system was put into operation, because the cloud of vapor coming from a manhole just outside the building was objectionable. Yet this was not associated with the large steam consumption of the system, it being attributed to the meter rather than to a fault in the heating system. After the trap was adjusted so as to work without sticking, the steam consumption of the system was reduced to 55 per cent of the amount formerly used.

Instances could be cited in great number where meters have shown such conditions to exist, the indications of which on the meter charts were first thought to be faults in the meter operations. All these instances, however, are of value if they indicate the advisability of studying the meter records and obtaining from them all the information possible.

Flow meters of course are not always correct and require some care and attention to produce the best results. I have used ten meters on continuous testing service for about six years, and they have given exceptionally good results under adverse operating conditions.

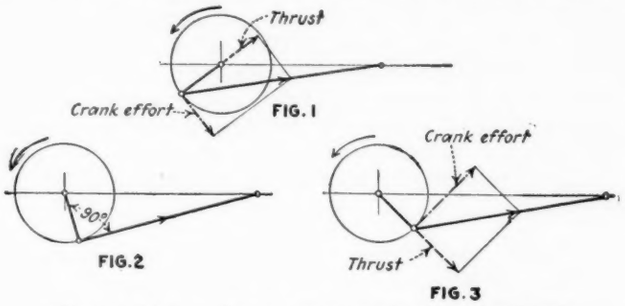
Dunmore, Pa. J. A. MAGUIRE.

Load on Main Bearing

In the May 16 issue of *Power* L. L. Collins gives an analysis of the force sustained by the main bearing cap of horizontal engines, which makes reference to my article on the same subject, which appeared in the issue of March 14.

Anyone familiar with the mechanics of the crank mechanism will see at a glance that the curve given by Mr. Collins represents the thrust on the crosshead guide instead of the force it was intended to represent. The curve evidently was drawn for a connecting-rod ratio of one to five, which is corroborated by the maximum thrust of 20 per cent of the piston load, which is one-fifth of that load and is as it must be. This is further substantiated by the formula $F = P \tan L$ from which this curve was developed and which gives the crosshead thrust, as can be found in any engineering handbook.

Mr. Collins goes on record as saying that the tangential force is applied at but one point of the crank-



FIGS. 1 TO 3. THRUST ALONG CRANK AT THREE CRANK ANGLES

pin circle, but at the same time refers to the crank-effort diagram, which, as everybody knows, gives nothing but just the tangential component of the connecting-rod force for every point of the crank circle.

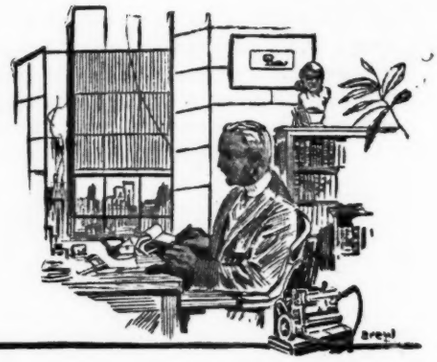
I will refrain from analyzing Mr. Collins' transformation of the thrust formula $F = P \tan L$.

From pure logical deduction it is evident that a thrust against the main bearing cap of a horizontal engine can obtain only during part of the return stroke —only during the first part of that stroke from dead center to the point when crank and connecting rod form a right angle. At this latter point the thrust disappears, and for the rest of the stroke the reaction will be downward instead of upward. To make the conditions clearer, I have shown three diagrams. The first one, Fig. 1, applies to the first part of the return stroke; the second one shows crank and connecting rod at right angles; and the third one, Fig. 3, applies to the last part of the stroke. The condition as shown in Fig. 2 takes place when the piston has traveled from 50 to 60 per cent of its return stroke, depending on the connecting-rod ratio.

My original article on this subject was mainly intended to give the designer of horizontal double-acting engines a line for the proportioning of this part of his engine, and for this reason the force sustained by the main bearing cap was expressed in percentage of the piston force as the most logical and most convenient. For the same reason no reference was made to inertia of moving parts, since inertia, as a variable force depending on the engine speeds, is not ordinarily considered when proportioning such parts of an engine.

Syracuse, N. Y. W. TURNWALD.

QUESTIONS AND ANSWERS



Expanding Tubes and Nipples of Water-Tube Boilers

Why are the tube ends and nipples of water-tube boilers simply expanded without being beaded over as required for tube ends of fire-tube boilers? J. H. T.

The object of beading over the ends of tubes of fire-tube boilers is to obtain better protection from the corrosive action of the fire and retain greater resistance against stripping action of the tube-sheet holes. The ends of tubes and nipples of water-tube boilers are not exposed to the action of the fire, and, if anything, properly performed expanding and flaring without beading has greater holding power, as beading over the ends is likely to produce splitting or disintegration of the material.

Submerged-Piston and Straightway Pumps

What is the difference between a submerged piston and straightway pump? M. C.

The main difference of design is in the location of the suction valves. In a horizontal submerged piston pump the suction and the delivery valve decks are both above the piston so that once the pump is charged with water it remains so. In a straightway pump the suction and discharge valves are in opposite sides of the pump cylinder, and the water flows through the passages in a practically unchanged direction.

When the piston of a pump comes to rest at the end of a stroke, the suction water does not necessarily come to a stop at the same instant, and owing to its inertia the water may continue to flow through the pump for a short time. In a submerged piston pump the water contained in the passage to the cylinder is brought to rest with more or less shock and loss of power; but in a straightway pump the water flows through the pump in a practically unchanged direction, and while its direction of flow is not absolutely straight, it is more nearly so than in the submerged piston type and there is less shock from bringing the piston to a full stop and reversing its direction of motion.

Location of Separator in Refrigrating System

Where should a separator be installed in the suction line of a refrigerating system? M. S.

The separator should be installed at a point high enough above the evaporating coils to insure a speedy drainage of the separator, also the drain line should be provided with a valve to close in case of pumping out.

The drain line from the separator can also be connected to a tank located below the separator for the liquid to drain into. This tank should be provided with a water jacket, with steam connection to keep the water hot for the purpose of re-evaporating the liquid ammonia, the gas piped back to the suction side of the compressor. In this way the tank serves the double purpose of converting the liquid from the separator into a gas and purifying the ammonia by separating out the oil or water that may have been taken into the system by leaks or inferior ammonia and the oil that works into the system from the compressor.

When the liquid from the separator is carried back to the evaporating coils, there is practically no loss from this source, as the liquid is re-evaporated and will do useful work in the transfer of heat, but the beneficial results of leading the separator drain to a purifier will more than offset the gain by the other method of re-evaporating the liquid in the coils.

Another system for removing liquid from the separator is to connect the drain line to an automatic drip tank and pump which is operated with a float and returns the liquid to the expansion or evaporating coils, the operation being the same as that of a pump and receiver used in a steam plant for returning condensate to the boiler.

Heating Water in Open Tank

What method can be used for heating 1,000 gal. of water per hour, from 60 deg. F. to 160 deg. F. for bathhouse purposes, the water to be heated in a 500-gal. open tank, using steam at 90 lb. gage pressure? How much steam would be required? J. T. C.

A simple method of heating water in an open tank is to employ an iron-pipe steam coil like a wall corner coil, placing one side of the coil about 6 in. above the bottom of the tank and the other side vertical. Heating 1,000 gal., or 8,333 lb., of water per hour from 60 to 160 deg. F. would require $8{,}333 \times (160 - 60) = 833{,}300$ B.t.u. per hour. The mean temperature of the water would be $(60 + 160) \div 2 = 110$ deg. F., and as the temperature of steam at the pressure of 90 lb. gage, or 105 lb. per sq.in. absolute, is 331 deg. F., the mean temperature difference between the steam and the water would be 221 deg. F., for which the heat transfer per degree would be about 200 B.t.u. per sq.ft. of iron pipe surface per hour. As each square foot of surface would transmit $221 \times 200 = 44{,}200$ B.t.u. per hour, for heating the water the coil would need to contain about 19 sq.ft. of surface, which would require about 70 lin.ft. of ¾-in., or 55 ft. of 1-in., or 42 ft. of 1¼-in. iron pipe, and about 10 per cent should be added to cover imperfect circulation and losses from radiation.

The latent heat of steam of 90 lb. gage pressure is 885.2 B.t.u. per pound, and transmission of 833,300 B.t.u. to the water per hour would require $833{,}300 \div 885.2 = 941$ lb. of steam per hour without allowance for heat that could be recovered in the condensate. If the water is heated by direct injection of steam, the heating would require about 810 lb. of steam per hour.

Care of Transformers

Could you give me some information relative to the general care and filtering of the oil of two 25-kva. 85,000-volt transformers used in Cottrell precipitators?

C. A. N.

Testing and filtering transformer oil was discussed in the Feb. 14 issue, giving recommendations of the N. E. L. A. Transformers of 25 kva. usually operate from two to four years without requiring the oil to be changed. If the transformer is overloaded continuously, one year may cause serious deterioration of the oil, and if moisture penetrates, the safe operating time will be shorter. The manufacturers generally issue instruction books, that are furnished on request. Be sure to give name-plate rating.

General care should include cleaning the insulators at regular intervals from one week to two months, depending on the amount of dirt encountered. Temperatures should be observed and recorded, once a day, or a month, depending on how near they are to maximum allowable temperatures. Once a year the windings should be lifted out and inspected. If a slimy deposit is present, the oil should be changed and everything cleaned up.

The oil should be tested for moisture at intervals of two to six months. Public-service companies usually have facilities for testing the oil at high voltage, and usually make such tests on request. A pint sample from the top and another from the bottom of the transformer should be submitted.

If no high-voltage testing is possible, the usual practical test is to boil some oil in a tin vessel. There will be crackling sound if moisture is present, lasting until it is boiled away. In order to judge this, stir the oil with a moist stick and see how small an amount of moisture will make itself known by this test. This is a reliable test, if repeated several times to make sure of the results. A test can also be made by thrusting a red-hot iron into a small quantity of the oil. Crackling will occur if moisture is present. High voltage tests as suggested should be made if possible.

It would hardly pay to purchase a special filtering device for such small transformers. If moisture is present or if the oil is not clear, it would probably be most economical to purchase enough oil for refilling one transformer, and then send the old oil where it can be filtered economically. If this costs too much, the old oil can be run through a lubricating-oil filter and used as a lubricant where high-grade oil is not required, such as for squirt cans, etc.

Be sure to use the grade of transformer oil recommended by the manufacturer, and make a hard-and-fast rule requiring all disconnects to be opened when cleaning the insulators.

Supplementary Governor

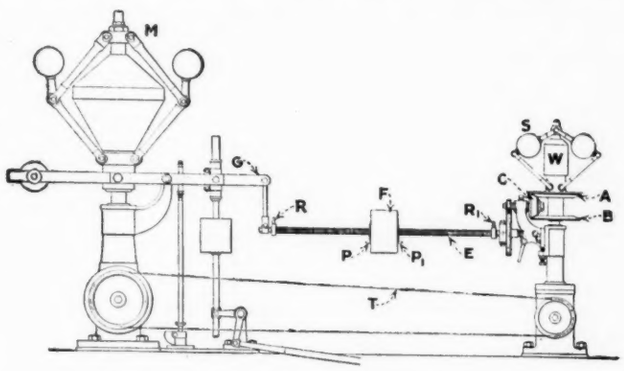
On an engine with a flyball governor, how is a supplementary governor arranged for obtaining uniformity of speed with variations of the load on the engine?

S. M. T.

Supplementary governors to compensate flyball governors of cut-off engines are used in two different ways. In one kind the supplementary governor is employed to vary the length of the connection between the main governor and the valve gear, and in another kind the supplementary governor, when not satisfied in speed, automatically loads and unloads the main governor.

The illustration shows a form of loading and unloading mechanism that has been used on engines of European cotton spinning mills. The supplementary governor *S* consists of a sensitive governor driven by a belt *T* from the main governor *M*. On the central weight *W* are two leather-faced bevel wheels *A* and *B*, and between these is a bevel wheel *C* mounted on a sleeve bearing that is supported by an adjustable bracket.

The size of *C* is such that a small vertical movement of the governor weight *W* due to a change in speed, causes one or other of the bevel wheels, *A* or *B*, to engage with and rotate the bevel *C*, which is geared to a long screw *E* on which rides a circular weight *F*. This weight is hollow, with internal ribs, and is about half filled with shot, causing it to travel along the screw *E* in preference to revolving with the screw when the latter is rotated by contact of the friction bevel wheel *A* or *B* with the friction bevel *C*. By this means larger or smaller proportions of the weight *F* is thrown on



SUPPLEMENTARY GOVERNOR FOR LOADING AND UNLOADING MAIN GOVERNOR

the loading lever *G* of the main governor *M*, according to the direction of motion imparted by the bevels *A* or *B* to the bevel *C* due to the supplementary governor standing higher or lower than its position for normal speed. Should the weight *F* reach the end of its travel along the screw *E*, a pin *P* or *P'* engages with a corresponding pin *R* or *R'* projecting from the screw. When thus engaged, the weight revolves with the screw, the shot inside of the weight falls to one side, and the weight is ready to start back again when the motion of the screw is reversed.

The main governor should be speeded so as to run at mid-height when the traveling weight is at mid-position on the screw; and at the desired speed, the supplementary governor either should not rotate the bevel wheel *C* at all or should move it first in one direction and then in the other. The desired normal speed is obtained by appropriate size of the belt pulley or can be varied over a considerable range by raising or lowering the adjustable bracket that supports the bevel wheel *C*.

Prompter regulation by the supplementary governor is obtained by making the screw *E* double-threaded, or by increasing the diameter of the bevels *A* and *B*.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Fire Hazards in Plants Using Pulverized Coal*

By L. D. TRACY
Coal Mining Engineer, United States Bureau of Mines

PULVERIZED coal in bulk is not especially hazardous but as soon as it is raised into a cloud and mixed with air it becomes as dangerous as an unconfined body of gas. It takes only a small quantity of coal dust per cubic foot of air to cause a very explosive mixture. In tests by the Bureau of Mines a mixture of 0.032 oz. of Pittsburgh Coal dust per cubic foot of air has been sufficient to cause an explosion when brought in contact with a flame. Perhaps this can be better understood when it is realized that all that is needed to produce an explosive mixture is the amount of coal dust that can be held on a silver quarter of a dollar mixed with the air contained in a 12 by 12 by 12-in. box.

Fire from Ignition of Dust Cloud

As an illustration of what such a combination of dust cloud and open lights may do, the fire in a coal-crushing plant connected with one of the steel mills in the Pittsburgh district may be cited. This was a simple plant used for crushing lump coal for automatic stokers at the boiler plant. The coal was dumped from the railroad cars into a small hopper that fed by gravity into the crusher. From the crusher the coal dropped through a chute to the foot of an elevator by which it was elevated to a small bin, whence it was delivered to railroad cars on a track depressed about twenty feet below the upper tracks. The elevator was partly closed on three sides, but at the front it was open on the side toward the depressed track. As the coal was dry, a cloud of dust surrounded the plant during the crushing operation.

Early one morning the chutes became clogged, compelling the crusher to shut down. Half an hour later five men went to the foot of the elevator to clean the chute. For lighting the elevator shaft, when such clogging occurs, there are two incandescent lamps, attached to a wooden crosspiece and connected by a flexible rubber covered wire to the regular lighting circuit on the platform. These lights were lowered when the men went below the platform, but to provide additional light, one of the men carried a lighted torch. A strong wind was blowing and extinguished the torch light. The last man had barely reached the bottom of the elevator when there was a burst of flame which killed three, badly burning a fourth, who died a few hours later at the hospital, and painfully burning a fifth, who recovered. The cause of this accident was supposed to have been the lighting of a match in order to relight the torch, which ignited the dust cloud at the foot of the elevator. A rather peculiar accident happened in one of the Pittsburgh steel mills. At one point in the building was an electric switch so situated that dust could settle between the poles. One Sunday when the mill was shut down and after sufficient dust had accumulated to form a short circuit, a whole panel of the switchboard was burned out.

Hazards Due to Apparatus Used

These incidents were practically due to the dusty and unclean condition of the buildings. There are some hazards, however, that are more or less connected with the apparatus used in pulverizing and delivering the coal. While it is true that the reduction of the fire and explosion risks rests largely with those operating the plant, much can be done through proper inspection. In order to understand properly these hazards and their remedies, a working knowledge of the methods and machinery used in pulverized fuel plants is necessary.

Generally speaking, there are three distinct classes of pulverized-coal equipment in general use, which may be designated as (a) the circulating system, (b) the indirect system and (c) the unit system.

In the circulating system, after the coal has been pulverized, it is fed in regulated quantities to a fan, by which it is forced in a cloud through pipe lines ranging from 8 or 10 in. in diameter to 14 or 16 in. Branch lines leading from the main line to the furnaces carry the coal as may be needed, the surplus which has not been drawn from the main line, returning to a separator which removes the coal dust from the air and returns it to a storage bin, again to be blown through the line. In other words, it is a continuous circulation of coal dust and is somewhat analogous to a gas line where the fuel is drawn off as needed. Secondary air lines, independent of the main coal feed line provide additional air at the burners necessary for proper combustion.

The indirect system transports coal either by compressed air under perhaps fifty or ninety pounds pressure, a screw conveyor, or a combination of air and screw conveyor to bins at the furnaces. From these bins the pulverized coal drops into a small screw conveyor by which it is either fed to an air blast which carries it into the burner, or fed directly to the burner.

The unit system differs from the previously described system in that the fuel is pulverized at or near the point of use and delivered from the pulverizer in a stream of air directly into the furnace by means of a fan which is a part of the pulverizer. An important feature of this method of utilizing pulverized coal as contrasted with the circulating and direct systems is the absence of a dryer to drive out the moisture.

Dryer the Cause of Many Fires

There are two types of these dryers, the direct-fired and the indirect-fired. The former consists practically of a long shell from three to five feet in diameter, at one end of which is a furnace and at the other end a stack. The hot gases pass through the center of the shell, coming in contact with the raw coal which is fed into the dryer at the stack end.

The indirect-fired dryer is generally one of two kinds. One kind is the double-shell type, in which there are two shells, one inside of the other, the raw coal traveling through the inner shell and the hot gases in the opposite direction in the space between the two shells and then returning through the inner shell to the exhaust stack.

The other kind is an inclined single shell, the higher end of which terminates in a brick housing supporting the exhaust stack, the lower end in a steel hood. The furnace for heating the dryer is placed between the stack chamber and the hood. The furnace is provided with a large combustion chamber through which the dryer shell passes. The hot gases from the furnace fire circulate around the outside of the dryer shell, passing through the combustion chamber of the furnace.

In the opinion of the writer the dryer is directly and indirectly the cause of a large proportion of the fires and explosions which have occurred in coal-pulverizing plants, and on the man running the dryer (and by that I do not mean the man in general charge, but the man actually shoveling the coal) is placed a great responsibility.

There was a fire in Ohio in a small amount of coal remaining in a compressed-air line. Some repairs were to be made to the line and the pressure was supposedly shut off as the gage registered zero. When the line was broken, a cloud of coal dust was blown directly toward the open door of the furnace dryer by a slight air pressure remaining in the line. Immediately there was a cloud of flame which filled the room.

In cleaning up a plant, coal dust should never be swept up with a broom nor should accumulations be dislodged from window ledges, girders, boiler housings or platforms by blowing with compressed air, unless they have been thoroughly wet down or mixed with incombustible dust in

*Excerpts of address before the Fire Chiefs' Club of Ohio, and published by permission of the Director of the United States Bureau of Mines.

the proportion of seven parts of rock or shale dust to one part of coal dust. There are some plants that I have seen that are kept almost spotless by a vacuum system.

Another safeguard is to see that the dryer is isolated from the rest of the pulverizing plant—if not in a separate building, then by a blank masonry wall.

All dryers should be equipped with recording pyrometers that make continuous records of the temperature. Preferably, this chart should be placed in the office of some responsible official, and the thermocouples, or that part of the pyrometer affected by the change in temperature, should be installed at the discharge end of the drier. One of the greatest sources of fire in a dryer room comes from the continuous passing of hot gases from the dryer furnace through the dryer shell when the dryer is not in operation. That is when the shell is not revolving and there is not a constant stream of coal passing through the dryer. In such a case there is likely to be a certain amount of coal lying in the dryer shell, which, by the continuous contact with the hot combustion gases, will in time become ignited. Then when the dryer is again put in operation, this hot coal will either be delivered to the pulverizer or to the dried-coal storage bin. If it goes to the pulverizer, it is likely to ignite and explode the fine dust therein; if to the dried-coal storage bin, there is a possibility of its starting a fire by spontaneous combustion. Or by the continued application of heat from the dryer furnace, gas may be generated from the coal in the dryer, collect in the shell and explode with disastrous results if brought in contact with an open flame.

Next to the dryer one of the most prolific sources of trouble is the large main that circulates the mixture of air and coal dust around the plant, returning the unused coal to the storage bin. The pulverized coal is driven through this line by air currents induced by a fan and having a pressure of about eight or nine ounces per square inch. The fires in this line are often of a smoldering nature, which heats the pipe red hot. Should you be called to extinguish such a fire, there is not much that can be done save cutting out the hot section. In any event the blowing fan should be stopped. And the most important precaution of all is that the entire line should be inspected to see that it is entirely free from sparks, glowing particles or smoldering coal before the fan is again started. Otherwise, there may be just enough dust lying in the bottom of the pipe line to make an explosive mixture when raised into a cloud by the starting of the fan, which will cause trouble if brought into contact with any glowing particles.

If a stream of water is poured on red-hot coal, there is a likelihood of carbon-monoxide gas being generated, and should the bin be in a confined space there is danger of men being overcome, as carbon monoxide is one of the most poisonous gases ordinarily met with, and a fraction of one per cent is deadly when breathed. In the case of a bin of pulverized coal, should a stream of water having any force be placed on the pile, there is the possibility of raising a cloud of dust and having it ignite.

Probably the quickest, safest and most economical way is to get all the coal out of the bin as soon as possible, and let it lie in a pile outdoors until the fire is entirely out.

Drying Out Large Power Transformers*

The question as to an effective method for drying out the windings of large power transformers has come up from time to time. The following description, furnished by one of the large manufacturing companies, outlines a plan that has given satisfactory results under actual trial and involves a comparatively simple and inexpensive equipment.

The apparatus required consists of a blower with driving motor, grid resistors mounted in an asbestos-lined box for heating the air and air ducts connecting this box to the transformer drain valve. Air is driven by the blower through the box with inclosed resistor and into the transformer case through the main oil-drain valve. By means of temporary blocking between the tank wall and the core and coils this air is caused to pass up through the ventilating ducts of the windings and escapes through the manhole opening.

The size of the blower and motor depends upon the volume of air required, and this in turn is determined by the size of the transformer and the number of units that are to be dried at one time. From 300 to 500 cu.ft. per min. will be required for each transformer.

The grid resistor should be proportioned to give a temperature rise of approximately 75 deg. C. to the air that is being forced through the transformer. With 25 deg. C. ambient air this will give a temperature of approximately 100 deg. C. to the air entering the transformer. Enough current should be circulated through the short-circuited windings to give a maximum temperature by resistance of 100 deg. C. The proportion of full-load current that this will require will depend on the volume and temperature of the circulating air and the inherent characteristics of the transformer.

Thermometers should be placed so as to read the temperatures of ingoing and outgoing air. The temperature of the transformer windings should be read, preferably by the rise in resistance method. The voltmeter-ammeter method may be used, but is undesirable, and for large units the serious consequences of excess temperatures will justify the use of a bridge. Where the transformers are provided with hot-spot temperature indicators, these will be found useful, but will not give a maximum temperature indication, owing to their reversed position with respect to the hot-air inlet.

The insulation resistances of both high- and low-voltage windings to the core and between high- and low-voltage windings should be measured by a megger. The temperature should also be recorded. It is important that these readings be taken at frequent and regular intervals, and the plotting of curves will be found useful in following the course of the drying. This should be continued until practically constant results are shown following two or three days of steadily increasing values of insulation resistance. As variations in temperature seriously affect the resistance of the insulation, it is essential that an accurate record of temperatures be kept.

Prior to the drying, the transformer should be thoroughly cleaned and inspected. All connections should be arranged so that at the conclusion of the drying the tank may be immediately filled with properly conditioned oil and sealed. This is important, as the heat stored in the transformer will establish a circulation of oil which will eliminate air bubbles from the ducts. The oil should be pumped in through one of the lower connections, or if this is not possible, the oil delivery pipe should be run down inside the transformer to the bottom of the tank to minimize the difficulty from this source.

There are certain precautions that should be taken in arranging the apparatus.

Provision should be made for some variation in the current through the resistor. This may be done either by regulation of the supply voltage or by taps on the grids.

In case the supply of air is interrupted, it is necessary to shut off the supply of power to the grids to prevent overheating and possible resultant fire.

Undue loss of heat should be guarded against by locating the heating chamber close to the transformer and by protecting the tanks from radiation by tarpaulins.

The blower intake should be screened with layers of cheese-cloth to prevent dirt and foreign material from being carried into the transformer. The number of layers may be adjusted to regulate the volume of air.

When several transformers are being supplied from one blower, proper division of the air should be secured either by adjustment of the drain-valve settings or by partial closing of the manhole openings.

*Abstract from N. E. L. A., Electrical Apparatus Committee's report.

Texas had 7,646 stationary engineers when the 1920 census was taken. This compares with 4,706, the number of stationary engineers in the state at the time the 1910 census was taken. Florida had 1,990 stationary engineers in 1920, as compared with 1,599 in 1910. Returns for the City of Buffalo show the number of stationary engineers to have been 1,886 in 1920, as compared with 2,082 in 1910.

Supreme Court's Opinion on State Water Rights

The text of Justice Van Devanter's opinion in the case of the State of Wyoming versus the State of Colorado has just become available. The decision was handed down June 5, but owing to the desire of Mr. Justice Van Devanter to make the decision known prior to the recess of the Court for the summer, he delivered the opinion from the bench prior to the completion of its text. It consists of 34 printed pages —an unusual length for a Supreme Court opinion. The more important pronouncements are contained in the following extracts from the decision:

We conclude that Colorado's objections to the doctrine of appropriation as a basis of decision are not well taken, and that it furnishes the only basis which is consonant with the principles of right and equity applicable to such a controversy as this is. The cardinal rule of the doctrine is that priority of appropriation gives superiority of right. Each of these states applies and enforces this rule in her own territory, and it is the one to which intending appropriators naturally would turn for guidance. The principle on which it proceeds is not less applicable to interstate streams and controversies than to others. Both states pronounce the rule just and reasonable as applied to the natural conditions in that region; and to prevent any departure from it, the people of both incorporated it into their constitutions. It originated in the customs and usages of the people before either state came into existence, and the courts of both hold that their constitutional provisions are to be taken as recognizing the prior usage rather than as creating a new rule. These considerations persuade us that its application to such a controversy as is here presented cannot be other than eminently just and equitable to all concerned.

The contention of Colorado that she as a state rightfully may divert and use, as she may choose, the waters flowing within her boundaries in this interstate stream, regardless of any prejudice that this may work to others having rights in the stream below her boundary, cannot be maintained. The river throughout its course in both states is but a single stream wherein each state has an interest which should be respected by the other. A like contention was set up by Colorado in her answer in Kansas vs. Colorado and was adjudged untenable. Further consideration satisfies us that the ruling was right. It has support in other cases.

Most of the opinion is devoted to matters of fact. The Court goes into detail pointing out the grounds on which its conclusions rest. There is some technical discussion and some statistical matter relating to the flow of streams and related subjects.

Ford Offer Denounced in House and Senate

The Ford offer for Muscle Shoals fared badly last week, in so far as the discussions in the House and Senate at Washington were concerned.

Probably the most important attack against the proposition was a report submitted to the House on Tuesday by Representative Kearns, Republican, Ohio, and signed by Representatives Morin, of Pennsylvania, Parker, of New Jersey, Crowther, of New York, Frothingham, of Massachusetts, and Ransley, of Pennsylvania, all Republican members of the House Military Committee, which has been considering the various Muscle Shoals propositions. The report expresses dissatisfaction with both the majority and the minority reports of the committee made previously to the House, and announces the intention of making public the "real facts" about the matter.

The report states with particular emphasis that the nation-wide publicity favoring the Ford offer is largely propaganda and that many of those who are sincerely in favor of Mr. Ford do not understand the real meaning of his offer. It is charged also that Mr. Ford would not be obliged by his contract with the Government to manufacture fertilizers indefinitely unless he could do so at a profit to himself, and that his expressed intention of producing a large amount of cheap fertilizer represents simply a successful attempt to gain the support of the farmer. Mr. Ford is accused of the intention of using the project largely for "the manufacturing of other articles, which he would be allowed to sell at any price that he might see fit." The report also questions his ability to produce fertilizers at a price considerably below the present one.

Answering the argument that Mr. Ford may be depended upon to do what is right, regardless of his contracts, the report points out that he cannot be expected to live throughout the 100-year term, and that after his death "we do not know in what unconscionable hands this plant will fall."

Perhaps the strongest criticism of the entire report is directed against the financial terms of the contract, which are declared to make of it a disgracefully one-sided bargain. It speaks very favorably of the Alabama Power Co. and of that company's offer of two and one-half million dollars for the Warrior, or Gorgas, extension, and declares this offer to be entirely fair and worthy of acceptance. It is also pointed out that Mr. Ford, after having obtained control of the project, could promptly sell the Warrior extension for this price, and so get back at once one-half of the five million dollars that he offers. The report characterizes as "frenzied finance" Mr. Ford's proposed method of retiring at the end of 100 years the fifty million dollars estimated as the additional cost of the two dams. "Men everywhere who understand this proposition condemn it in unmistakable terms," the report continues; "the entire people will at some time know what fraud is being attempted, and then the condemnation will be universal."

In the Senate a fling was taken at the Ford offer by Senator Norris, chairman of the Committee on Agriculture, who said, "If this proposition had been made by Rockefeller, or the International Harvester Co., or the United States Steel Corporation, there would have been the greatest denunciation coming from some of those who are advocating the acceptance of the Ford offer." Senator McNary, of Washington, said that the proposed contract would "fall under the control of Wall Street within three days after Mr. Ford's funeral." Senator Heflin, of Alabama, declared that Mr. Ford would dispose of the property in his will so that it would not fall into the hands of anyone not in sympathy with his altruistic purpose. He felt certain that most of the power developed at Muscle Shoals would be used by Mr. Ford in making fertilizer, which was denied by Senator Norris.

New York Car Service Impeded by Inferior Coal and Emergency

Owing to the failure of a 30,000-kw. turbo-generator in the Seventy-fourth Street power house and poor grade of coal, the New York transit systems supplied from the Interborough power houses were badly crippled during the rush hour on Monday evening, June 19. At 3:20 p.m. a 30,000-kw. turbo unit sustained a short-circuit at the collector rings, causing its withdrawal from service. One other turbine of the same capacity was undergoing repairs in this station and a third 30,000-kw. unit at the Fifty-ninth Street station, so that reciprocating engines were called upon for service. The load was carried satisfactorily until the peak which occurred at 6 p.m.

In spite of the usual reserve capacity carried by the boilers, they were not able to handle this peak, owing to a combination of circumstances. The engine units required much more steam per kilowatt-hour than the turbines, which caused an unusual demand on the boilers. Coal of an inferior and variable quality was being used as a result of the coal strike preventing the usual supply. In all probability the peak could have been handled satisfactorily with the poor quality of coal had it not been that an unusually inferior grade reached the fires in the Seventy-fourth Street Station at the time of the peak load, causing excessive ash, which impeded the air supply and caused the steam pressure to drop rapidly. The steam-driven blowers slowed up so that it was impossible to carry the load, although the Fifty-ninth Street Station supplied all that was possible. Extra boilers have since been placed in service to carry the load until one of the steam turbines is available.

Using Exhaust Energy in Reciprocating Engines*

By J. Stumpf and C. C. Trump

The use of kinetic energy in long exhaust pipes has often been attempted in gas, gasoline and oil engines, especially in the two-stroke-cycle type, to improve the scavenging effect and increase the power output. Successful results were usually obtained more from a method of trial and error than from any attempt at design, or the use of nozzles, diffusers, etc., which might avoid losses and improve the effect.

A unaflow steam cylinder may likewise be provided with a number of exhaust nozzles and a long pipe. The nozzle in the cylinder is difficult to design for best efficiency because it is opened relatively slowly by the piston near the end of its stroke. The other end of the pipe should have some kind of diffuser for reducing the velocity energy to pressure energy, and this end is also not easy to design. The action of the pipe itself would seem to depend upon the following several variable factors: (a) The speed of the engine and number of exhaust puffs per minute; (b) the variation of pressure at and after release at the cylinder; (c) the variation of pressure at the other end of the pipe; (d) the area of the nozzles and exhaust pipe; (e) the length of the pipe; (f) the duration of the exhaust period; (g) the compression and expansion of the steam or gas itself; (h) heating due to friction; (i) cooling due to outside temperature conditions.

Provision for Load Variation

For engines running at moderate and nearly constant speed, the pipe length may be fixed and the area designed to give the best suction effect at the most desirable load. Variation of load can be provided for by extra nozzles and exhaust pipes which may be thrown in or out of action by the engine-governing system. Another method would be to provide an exhaust pipe in the form of a coil, with valves which would change connection between cylinder nozzles and diffuser so as to vary the length of the pipe. This might be necessary with variable-speed engines.

With single-cylinder engines the length of exhaust pipe necessary to produce the maximum suction effect may be too great for practical uses. As with a musical instrument, however, each vibration of the medium in the pipe may have its harmonic, or at least will be followed by other pulsations of reduced amplitude. If the second or third pulsation is caught at its lowest pressure as the exhaust ports close, instead of the first, the pipe will have to be only one-half or one-third as long, respectively. The effect of friction losses and cooling may change the exact length, but the result will be in favor of the shorter pipe.

Calculations for the proper length of exhaust pipes involves so many variables that it is probably easier to choose a reasonable size of pipe and arrange the cylinder with approximately the proper nozzles, then cut and try with different lengths of pipe and with a sensitive spring indicator on the engine until the best length is found. It may be interesting to suggest the use of graphical curves of pressure-volume, energy-volume and energy-time as a means of arriving at the approximate design with which to start experiments.

Overlapping Exhausts

For multiple-cylinder engines, especially those that run at high speeds, the periods of exhaust will overlap, and by proper design of nozzles one exhaust may be made to draw on the other.

It is evident that with four exhaust puffs per revolution it is necessary to take account of the vibratory action of the exhaust pipe. Its length and volume and the cooling and friction loss must be fixed either by calculation or by experiment, or in combination. With six or more exhaust puffs per revolution the suction effect may be almost entirely produced by ejector nozzles, so paired as to co-operate and induce partial vacuum in each cylinder at the instant when the exhaust port is closed, at the beginning of compression. Even in this case it may be necessary to proportion the exhaust pipes, in length and volume, so that adverse vibrations may not be set up to spoil the vacuum.

Single-acting engines of four cylinders and less will evidently require longer exhaust pipes than those of six cylinders and more. The higher speeds at which these engines are usually run will tend to reduce the necessary pipe length. All the benefits of the exhaust ejector action accrue to single-acting engines, except that when the pistons control the exhaust ports they cannot be made shorter.

Ordinary counterflow steam engines with exhaust valves, or with a single valve for admission and exhaust, not only would be difficult to arrange with suitable nozzles to avoid eddy losses, but the exhaust period is usually made too long to be covered by the larger pulsations of the long pipe, or the ejector effect of other nozzles. A cylinder with exhaust ports, like a two-stroke-cycle gas engine or a unaflow steam engine, can be provided with almost unlimited exhaust-port area, and the exhaust period can be controlled, to be long for high speeds or short for low speeds. For non-condensing work, such as in locomotives, automotive vehicles and a large proportion of our stationary engines, the number of ports may be reduced to one, two or three, and the exhaust belt of large diameter dispensed with. Smaller nozzles may be provided for bleeding steam, after it has done useful work, for heating cars or feed water. Such nozzles may also be used for supplying steam for process work or for heating, with a small part of the exhaust from stationary engines. The long exhaust pipe and ejector action may also be used to reduce the clearance volume required to control compression, or to dispense with exhaust valves, when it is desired to operate the engine with exhaust against back pressure higher than atmospheric, and use all the steam for heating or process work.

The practical application of long exhaust pipes, receivers, nozzles, etc., is by no means so difficult as their proper design. Experience with Humphrey pumping engines of all sizes has shown that the inertia effect of long pipes may be a decided detriment to efficiency in some cases, but may be turned to decided advantage if properly utilized and controlled. One of the authors has seen the capacity of these internal-combustion engines improved 50 per cent simply by changing the length of exhaust pipe. Fortunately, the graphical methods of design developed for Humphrey pumping engines may be easily adapted to new uses. Ways must be found to take account of more variable factors (nine or ten in this case), but that is easier by graphical than by any other method. It may, however, take some time and experimental work to determine the practical coefficients.

Long exhaust pipes and proper nozzles, however, do provide a means of controlling compression, which in a unaflow engine serves to improve thermal conditions, as well as mechanical cushioning, for which it is mostly used in ordinary steam engines. They avoid large clearances in non-condensing engines, or the alternative of mechanically operated exhaust valves, which the condensing unaflow engine has already dispensed with.

*Extract of paper read before the spring meeting A. S. M. E., Atlanta, Ga.

The City of Louisville, Ky., has applied to the Federal Power Commission for a preliminary permit covering a power development at the United States Dam in the Ohio River at the Falls of Louisville. The dam and the lock at that point have been recommended for reconstruction. Primary power to the extent of 28,000 hp. would be available at that point, it is estimated. The city plans, however, to install equipment capable of generating 50,000 horse power.

The Smith-Sanders Power Co., of Rogersville, Tenn., has applied to the Federal Power Commission for a preliminary permit covering a power project in the Holston River in Hawkins County, Tennessee. The estimated primary power that will be developed is 15,000 hp., and it is the intention to install equipment sufficient to generate 25,000 hp. The power is to be used for public utility purposes.

News in the Field of Power

Carrier Current Tests Prove Successful

Considerable research work has been carried on lately in an effort to work out a system by which electric power transmission lines might be used for communicating between plants and for operating switches or other devices from a distance, without interfering with the main current being carried over the wires. Promise of successful results from this work is indicated by the report that a demonstration of the remote control of relays operating a street lighting circuit and other devices by the use of a so-called "carrier current" was recently made at the plant of the Lynn (Mass.) Gas and Electric Co.

From the plant at Lynn, the carrier current system successfully controlled two circuits at Little Nahant, four miles distant, and was made to operate 18 incandescent and two arc lamps on one of the circuits and two 1,000-watt searchlights, two 500-watt floodlights and a pendant lantern on the other circuit.

In the sending station, a high-frequency generator with vacuum-tube unit was used to convert the ordinary 110-volt 60-cycle household lighting current into power at the much higher carrier frequency. The output of this generator was then superimposed on the 4,400-volt feeder line running to Little Nahant. This line travels underground for a mile and above ground for the remainder of the distance of four miles.

The relays in control of the two circuits were arranged to operate at different carrier-current frequencies and could thus be made to operate separately by varying the carrier-current frequency. The apparatus tested was turned off and on at the will of the operator in the central station at Lynn.

Although the system has not yet been perfected in all details, it was pointed out that enough preliminary work has been done to indicate practical advantages of the carrier-current system, first as an aid to the solution of the central-station communication problem and, as in the recent tests, its extension into the operating field. It is stated that any number of relays can be operated by the carrier current, thus controlling a number of separate circuits for various purposes.

Steam Engine Tariff Down

Yielding to objections voiced by Senator Jones, N. M., who has opposed practically ever item in the tariff bill, the Senate Finance Committee acceded to a demand to reduce the duty on steam engines and steam locomotives from 20 to 15 per cent. Senator Jones referred to this duty as a "colossal" mistake, because of the size of the articles and the extent of the industry. He referred to the stupendous production of steam engines and locomotives in this country, mentioning the large exports of these articles as contrasted to the small imports.

Stevens Awards Degree of M.E. To 112 Graduates

At the fiftieth annual commencement of Stevens Institute of Technology, Hoboken, N. J., held on June 20, the degree of mechanical engineer was awarded to 112 graduates, the largest number in the history of the college. This year is the twentieth of the presidency of Dr. Alexander C. Humphreys, who was heartily congratulated by the alumni and friends of the Institute for his successful administration.

Safety Exhibit at Philadelphia

Commissioner Clifford B. Connelley, of the Pennsylvania Department of Labor and Industry, is promoting the idea of a permanent Safety Museum, comprising an international exhibit of safety appliances, in connection with the Sesquicentennial Exposition to be held in Philadelphia in 1926. The commissioner's plan has been laid before those arranging for the exhibition, and is reported to have met with the approval of Governor Sproul and other people of prominence connected with the movement.

It is thought probable that this exhibit will be the principal contribution of the State of Pennsylvania.

New Officers of A. A. E.

A. N. Johnson, dean of engineering at the University of Maryland, was declared elected for the ensuing year as president of the American Association of Engineers at its eighth annual convention in Salt Lake City, June 5-7. George E. Taylor, a consulting engineer, of Charleston, W. Va., and A. M. Knowles, structural engineer with the Erie R.R. Co., were announced as first and second vice-presidents respectively.

There was considerable discussion as to where the next convention should be held, and it was finally recommended that the following cities be considered: 1923—Norfolk, Va.; Atlanta, Ga.; Louisville, Ky.; Columbus, Ohio; 1924—San Francisco, Cal.; 1925—Portland, Ore.; 1926—Philadelphia, Pa.

The treasurer reported that the total income of the association from all sources, for the year ended April 30, 1922, was $218,176.84, of which $113,067.98 was returned to the chapters for local work.

Senate More Generous with the Navy

An increase of $2,695,000 in appropriations for the Navy Bureau of Engineering for the fiscal year beginning July 1, over the appropriations allowed by the House, is recommended by the Senate Committee on appropriations in reporting the naval appropriation bill.

"The committee is of the opinion from evidence presented to it that the Navy department, through the present chief of the Bureau of Engineering, Admiral John Keeler Robison, is exerting every effort to bring about the utmost economy in the maintenance and operation of the navy," says the committee in its report. "Many economies have already been put in force under the present head of the bureau, particularly in the adoption of new processes and regulations for the saving of fuel. When the size of the navy as provided in this bill was increased by the action of the House from 67,000 as reported to the House to 86,000, no corresponding increase was provided by the House in the bill in the item of engineering. Plans of the department were to keep in commission a much less number of ships if 67,000 men only were allowed than they expected to keep in commission with a force of 86,000 enlisted men."

Tidal Project May Be Started

Straight Bay, near the international boundary between Maine and New Brunswick, may be the scene of an extensive hydro-electric project involving the use of tidal power. On account of the tremendous rise and fall of the tides along the coast of New Brunswick (in some cases up to 30 ft. and more) the possibility of a tidal project in that district has been discussed for some time.

It is said that present plans for the development at Straight Bay call for a canal 270 ft. long and 150 ft. wide, arranged so that the tides can be used at both flow and ebb. It is reported that plans have progressed so far that there is already considerable activity in the way of buying and selling land near the site of the proposed development.

The New York State Civil Service Commission is looking for assistant engineers (gas) at $3,000; assistant steam engineers for state and county hospitals, departments and institutions, at from $900 to $1,500 (with maintenance); and lock operators on the Barge Canal at $125 per month, with opportunity for promotion to $2,100 per year. Application forms for written examinations must be filled out and mailed by July 3, or delivered at Albany by July 5. The blanks may be obtained by addressing the State Civil Service Commission, Albany, N. Y.

New Publications

Plumbers' Handbook. By Samuel Edward Dibble, Head of Heating, Ventilating and Sanitation Department, Carnegie Institute of Technology. Published by McGraw-Hill Book Co., Inc., New York City, 1922. Cloth, 4½ x 7 in.; 629 pages; 316 illustrations. Price, $4.

This book consists of a compilation of reference data, and has been prepared with a view to being of permanent value to the plumbing and heating engineer. It covers briefly but in a practical manner the different phases of plumbing and its allied trades. The work is divided into sixteen chapters: Heat, pumps, oxyacetylene welding, general plumbing section, fittings, pipe standards and pipe dies, vitrified clay sewer pipe, gas fitting, plumbing fixtures, metallurgy and chemistry, sheet-metal work, heating, mathematics, codes, glossary of plumbing terms, business methods.

Proceedings of the Thirteenth Annual Convention of the International Railway Fuel Association. Published by the Association at 702 East 51st St., Chicago, Ill. Cloth, 6 x 9 in., 333 pages. Price $3.

A word-for-word report of the sessions of the Association's annual convention at Chicago last year, May 24-26. Not only all the speeches, but also the discussions are given in full. While much of the material included is of considerable interest and value, it is too bad that it cannot be made available sooner than a year after it was prepared.

Among the many speeches printed are: "Fuel Conditions on the French Railways," by M. de Boysson, Ing.; "Preparation and Distribution of Fuel," by E. P. Bast; "Essential Items of Cost in the Production of Coal," by Mont B. Morrow; "Standards of Fuel Economy Practice," by D. C. Buell. Reports are given of the committees on Locomotive Feed Water Heating, Storage of Coal and Fuel Department Organization. A speech on "Oil-Shale as a Source of Oil Supply," by Martin J. Gavin, is also included.

Personals

Jas. R. Coe, former president of the N. A. S. E., is superintendent of the Gotham National Bank Building, 1819 Broadway, New York City.

J. F. Geiger has resigned as head of the Boiler Inspection Department of the State of Indiana to accept a position as foreman boilermaker for the C. E. & I. R.R. at Salem, Ill.

T. E. Tucker, president of the Gem City Boiler Works, won the president's cup offered for the lowest gross golf score for the two days' play at the Shawnee meeting of the A. B. M. A. Other winners were G. E. Ryder, of the Superheater Co.; Chris. Cunningham, president of the Christopher Cunningham Co.; Charles Tudor, of the Tudor Boiler Works; R. M. Powers, of Kewanee Boiler Co., Kewanee, Ill.; and J. E. Mason, of *Power*. Mesdames A. G. Pratt and A. R. Goldie respectively won the first and second prizes in the putting combat.

Prof. Charles Hyde Warren has succeeded Russel H. Chittenton as director of the Sheffield Scientific School at Yale. Prof. Warren is a graduate of Yale, in the class of 1896, but since 1900 has been on the faculty of the Massachusetts Institute of Technology. Dr. Chittenton, also of Yale, has been head of the Sheffield School since 1898. He tendered his resignation a year ago.

Coming Conventions

American Society for Testing Materials, 1315 Spruce St., Philadelphia, Pa. Annual meeting at Atlantic City, N. J., June 26-July 1.

Canadian Association of Stationary Engineers; G. C. Keith, 51 Wellington St. West, Toronto, Ont. Annual convention and exhibition at Kitchener, Ontario, June 27-29.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual conventions and exhibitions of the State Associations scheduled as follows:

Connecticut, at New Haven, June 23-24; Fred C. Sutorius, 890 Chapel St., New Haven.

New England, at Springfield, Mass., July 12-14; James Morgan, 53 Devonshire St., Boston.

Michigan, at Kalamazoo, July 19-21; A. M. Adams, 1307 Stockbridge Ave., Kalamazoo, Mich.

Wisconsin, at Madison, July 26-28; C. Z. Wise, 204 South Carroll St., Madison.

Minnesota, at Minneapolis, Aug. 9-11; C. A. Nelsen, 800 22nd Ave., N. E., Minneapolis.

Iowa, at Des Moines, Sept. 10-11; Abner Davis, Room 16, Waterhouse Block, Cedar Rapids, Iowa.

Universal Craftsmen Council of Engineers; Thomas H. Jones, 33 Linden Ave., Cherrydale, Va. Annual convention and exhibition at Cleveland, Aug. 7-11.

Business Items

The Pennsylvania Pump and Compressor Co. has opened a new district office at 105 West Monroe St., Chicago, Ill., with H. M. Montgomery in charge.

The Pioneer Rubber Mills, San Francisco, have opened an Eastern sales office at 50 Church St., New York City, and will carry a complete stock of their mechanical rubber goods in New York warehouse. This new office, with D. D. Tripp, vice-president, in charge, will serve the Mississippi valley and the East. W. L. Rogers will continue in charge of "Skookum" packing sales.

The General Electric Co. has made a number of changes in its personnel. J. G. Barry, sales manager since 1917, and manager of the railway department for many years, and A. H. Jackson, of the law department, have been elected vice-presidents, and Walter S. Goll has been appointed manager of the Fort Wayne (Ind.) works to succeed F. S. Hunting, who recently resigned. Mr. Barry is 52 years of age, and has been with the G.E. company and the Thomson-Houston Co. for thirty-two years. Mr. Jackson is 58 years old, joined the company in 1902, and has been for some years head of the law department. Mr. Goll, a graduate of Sibley College, at Cornell University, has had wide experience in railway engineering.

Orton & Steinbrenner Co. has moved its offices from the eleventh floor of the Transportation Bldg., 608 South Dearborn St., Chicago, Ill., to larger quarters on the nineteenth floor of the same building.

The Webster Manufacturing Co., Chicago, Ill., has announced the appointment of Walter J. Evans as manager of the Philadelphia sales office, with headquarters in the Commercial Trust Building.

The David Fitzgibbons Boiler Corporation, Oswego, N. Y., has been organized, and the withdrawal from the Fitzgibbons Boiler Co. of David Fitzgibbons and D. T. Fitzgibbons has been announced.

The Copper and Brass Research Association, 25 Broadway, New York City, has offered $1,000 in cash prizes for the best photograph that may be submitted to it showing the durability of copper, brass and bronze, and the failure of substitutes.

The American Abrasive Metals Co., 50 Church St., New York City, manufacturer of a number of anti-slip treads, has been appointed by the Carborundum Co., of Niagara Falls, as United States representative for the sale of the Carborundum anti-slip tile.

The Sanford Riley Stoker Co. has merged its interests with the Underfeed Stoker Company of America and its affiliated companies, the A. W. Cash Co., valve manufacturers, Decatur, Ill., the Craig Damper Regulator Co., Detroit, Mich., and the Underfeed Stoker Co., Ltd., of Canada. Manufacturing will be concentrated at Detroit, Mich., and Worcester, Mass. R. Sanford Riley becomes president of the combined companies, with F. H. Daniels as vice-president. S. A. Armstrong continues as vice-president and managing director of the Underfeed Stoker Company of America.

Trade Catalogs

Reducing Valves—Atlas Valve Co., 282 South St., Newark, N. J. An educational handbook of rules, tables, curves, etc., for showing the right size of reducing valve to use under any given conditions, and also showing the capacity and the flow of steam in pipes of different diameters and different losses in pressure.

Velocity Stage Turbines—De Laval Steam Turbine Co., Trenton, N. J. A 28-page catalog describing a line of velocity stage turbines especially designed for high-pressure and high-temperature steam. These turbines are built in sizes up to 1,200 hp. and are meant to be coupled to high-speed centrifugal pumps and blowers, small gen-

erators, etc., directly, or to slow and moderate-speed machinery through double-helical speed-reducing gears.

Steam-Ash Conveyors — Conveyors Corporation of America, 326 West Madison St., Chicago, Ill. Short booklet on performance and the construction of steam ash-handling equipment.

Malleable Nickel—American Nickel Corporation, Clearfield, Pa., Bulletin No. 101, giving the physical properties, advantages and uses of malleable nickel. Among the uses mentioned are boiler and condenser tubes, refrigerating equipment and turbine blades or buckets.

Small Steam Turbines—London Steam Turbine Co., Troy, N. Y. (Successor to the Steam Motors Co.). Bulletin No. 14, describing and illustrating the construction, advantages and special features of the company's line of single-stage steam turbines of the one-bearing type, which are built in sizes up to 500 hp. for stationary or marine use.

Steel Sash, Casements, Etc.—David Lupton's Sons Co., Allegheny Ave. & Tulip St., Philadelphia, Pa. General catalog No. 11, 8 x 11 in., 191 pages. An elaborately prepared catalog on an extensive line of skylights, shelving and other metal products used in the construction of factories, power plants and other industrial buildings. The book should be invaluable to those who intend to build or remodel a plant. The company has also issued an exceptionally beautiful catalog on steel windows for apartments and residences.

Powdered Coal Data — Combustion Engineering Corporation, Broad St., New York City. "Powdered Coal Application to Four 2,640-hp. Boilers," a 15-page pamphlet in which is reprinted a paper presented last year before the Engineers' Society of Western Pennsylvania, with the addition of some highly interesting figures obtained from the performance records of the installation since the paper was first presented. The installation in question is at the Ford plant at River Rouge and is, therefore, of great importance.

Fuel Prices

FUEL OIL

New York—June 22, Port Arthur light oil 22@25 deg. Baumé 3¼c. per gal.; 30@35 deg., 4¼c. per gal., f.o.b. Bayonne, N. J.

Chicago—May 20, for 24@28 deg. Baumé, 85@90c. per bbl.; 21@36 deg., 3⅜@2½c. per gal. in tank cars, f.o.b. Oklahoma refinery, or freight adjusted to conform.

Pittsburgh—June 21, f.o.b. refinery, Pennsylvania, 36@40 deg., 5¼c.; Kentucky fuel oil, 26@30 deg., 3⅜c. per gal. Gas oil, 32@34 deg., 3c. per gal.; 36@38 deg., 3¼c.; 38@40 deg., 3½c. Western. 24@30 deg., 85c. per bbl.

Philadelphia—June 19, 26@28 deg. Baumé, Oklahoma, 95c.@$1.00 per bbl.; 30@34 deg., Oklahoma (group 3), 3¼@3¼c. per gal.; 16@20 deg. eaboard, $1.15@$1 255 per bbl.

Cincinnati—May 27, for 26@30 deg. Baumé, 5½c.; Diesel 32@24 deg., 5½c. per gal.; distillate 39@40 deg., 6c.

Cleveland—May 27, 26@30 deg. Baumé, 4¼c. per gal.

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run bases, f.o.b. mines):

Coal	Market Quoting	June 12, 1922	June 19, 1922
Pool 1,	New York	.....	$4.25–4.50
Smokeless,	Columbus	$3.50	3.25–3.40
Clearfield,	Boston	3.00–3.50	2.85–3.25
Somerset,	Boston	3.00–3.50	3.00–3.40
Kanawha,	Columbus	3.25–3.50	3.15–3.35
Hocking,	Columbus	3.50–3.75	3.00–3.25
Pittsburgh No. 8	Cleveland	3.60–3.75	3.60–3.75
Franklin, Ill.,	Chicago	.....	.....
Central, Ill.,	Chicago	.....	.....
Ind. 4th Vein,	Chicago	.....	.....
West Ky.,	Louisville	3.75	3.65–3.90
Big Seam,	Birmingham	1.75–2.00	1.75–2.00
S. E. Ky.,	Louisville	3.50	3.00–3.50

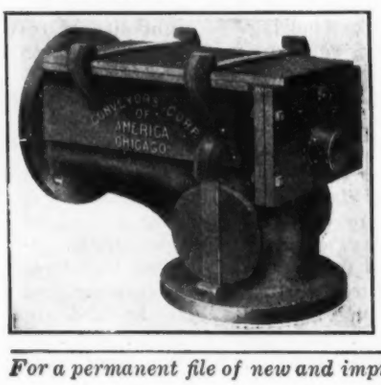
Condensed-Clipping Index of Equipment

For quick reading and convenient filing. These items have not been published before in "Power"

Plug, Fusible "Power," 1922.
Vulcan Boiler and General Insurance Co., Ltd., 67 King St., Manchester, England.

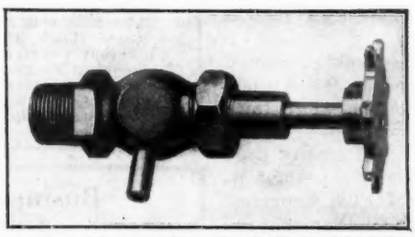
The interesting feature of this plug is that it gives the fireman warning of low water even if there is no steam pressure in the boiler. The center part of the plug is made of copper and is held in place in the upper part by a fusible alloy. The heat of the fire is conducted through the copper stem to this alloy, so that when the water level falls below the point at which the plug is located, the alloy melts and the copper part drops out. It is kept from dropping into the fire, however, by the bottom flange, which catches on webs in the bottom of the shell; the stem projects into the furnace so that it may be seen by the fireman, in the case of internally fired boilers, for which the device is particularly intended. In case the boiler is under pressure the plug, of course, functions in the usual way, and the fireman is warned by the escape of steam. The plug illustrated is screwed in from the water side; another model is applied from the furnace side.

Conveyor, Steam Ash "Power," 1922.
Conveyors' Corporation of America, 326 West Madison St., Chicago, Ill.



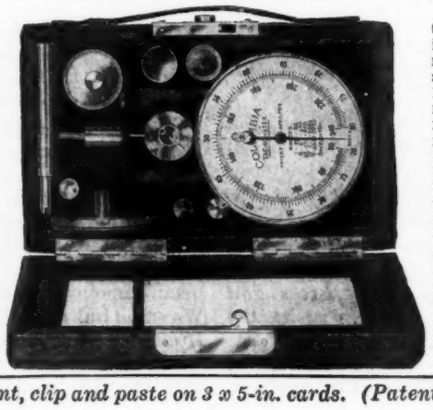
An improvement has been made in the 90-deg. steam unit of the American steam ash conveyor, making it easier to change the renewable liners. As shown in the illustration, the top cover plate is now held in place by clamp bars that are wedged in place under heavy lugs on each side, instead of by screws, as was formerly the case. The new fitting has the same over-all dimensions as the old one, but is made only in the 8-in size.

Valve, Try-Cock "Power," 1922.
Ernst and Co., Newark, N. J.



The feature of this cock is the ease with which it may be repaired when the seat wears. The valve spindle can be taken out and a new washer put in under full boiler pressure without difficulty in about one minute. This is made possible by a check valve arrangement consisting of a ball that is held off its seat by an extension on the end of the valve spindle until the spindle is screwed out almost to the end for removal. Then the ball seats, preventing steam or water from escaping. It is therefore possible to unscrew the packing nut and take out the entire spindle, on the end of which is a washer-holder that can be slipped off in a few seconds. A new one can then be inserted quickly. A few extra washer-holders may be kept on hand so that the washers, which are held on by a small nut, can be changed at leisure. The sprocket on the outer end of the valve stem is for use with a chain on high boilers.

Tachometer, "Columbia" Hand "Power," 1922.
Schaeffer & Budenberg Manufacturing Co., Brooklyn, N. Y.



An improved hand tachometer made in two speed ranges, covering speeds from 20 to 16,000 r.p.m. One model is for speeds from 20 to 8,000 r.p.m., and the other from 40 to 16,000 r.p.m. The instrument itself weighs 13 oz., and the entire case, with the tachometer and the attachments in it, weighs 1 lb. 10½ oz. The dial is 3 in. in diameter. A patented oiling system is provided.

For a permanent file of new and improved power-plant equipment, clip and paste on 3 x 5-in. cards. (Patented Aug. 20, 1918.)

New Plant Construction

PROPOSED WORK

Cal., Exeter—The Union School District plans election to vote $150,000 bonds for additional school buildings and installation of heating plant in present structure.

Cal., Marysville—The city is having plans prepared for dredging, cleaning out Ellis Lake and installing 8 in. pump, 10 ft. lift. Estimated cost $50,000. W. Meek, Engr.

Cal., Pasadena—The Bd. Educ., Chamber of Commerce Bldg., has voted $1,340,000 bonds for building schools.

Cal., Redwood City—Trustees of Sequoia Union High School Dist. are having revised plans prepared for three 1 story buildings on Broadway and State Highway. Estimated cost $300,000. C. Werner and A. I. Coffey, Humboldt Bank Bldg., San Francisco, Archts. Former bids rejected. Noted Dec. 20, 1921.

Cal., Westley—Easley & Anderson, Engrs. Antioch, are preparing plans for about 8 miles of ditches, etc., pumping plants, two 12 in. horizontal centrifugal pumps, direct connected 250 hp. motors. Owner's name withheld.

Conn., Farmington—The Union Electric Light & Power Co., Unionville, plans addition to hydro-electric power plant on the Farmington river here; also install new generating machinery. Estimated cost $100,000.

Fla., Jacksonville—The Milldale Ice Co., S. Simmons, Mgr., 1010 East Bay St., plans to build ice manufacturing plant. Estimated cost, including machinery, $35,000. Prices wanted on machinery and equipment.

Ga., Columbus—The Columbus Power Co., and subsidiaries, the Columbus Railway Co., and the Gas Light Co., plan to build additions and make improvements to 3 power plants. Estimated cost $700,000.

Ga., Columbus—The Dixie Brick & Tile Co., 1019 Broad St., is in the market for two 200 hp., 3 phase, 550 volt, 3 bearing motors (used), also cross arms, insulators, wire, transformers, etc.

Ga., Waynesboro—G. Vinson is in the market for 3 electric motors, 25, 50 and 75 hp.

Ill., Chicago—A. S. Ahlschuler, Archt., 28 East Jackson Blvd., will soon receive bids for mail order house on Jackson Blvd. and Rockwell St., for the Chicago Mail Order Co., Indiana and 29th Sts. First unit calls for 8 story building, including steam heating system, to cost $1,000,000. Total cost $4,000,000.

Ill., Chicago—The Chicago Electric Co., 740 West Van Buren St., is in the market for 300 or 350 hp. 200 r.p.m. steam engines d.c.

Ill., Chicago—S. Edison, c/o A. Anis, Archt., 127 North Dearborn St. is having plans prepared for 6 story, 64 x 140 ft. apartment building, including steam heating system, on Brompton Ave. Estimated cost $650,000.

Ill., Chicago—E. E. Hall, Archt., 123 West Madison St., will soon receive bids for 4 story, 200 x 200 ft. apartment building including steam heating system, near South Shore Drive and 75th St., for W. E. Gehring, c/o architect. Estimated cost $500,000.

Ill., Chicago—W. H. Hess, c/o H. O. Stone & Co., 111 West Washington St., plans to build stores, shop and hotel, including steam heating system, on Diversey Blvd. and Lehmann Court. Estimated cost $1,000,000. Architect not selected.

Ill., Chicago—The Illinois Women's Athletic Assn., 820 Tower Court, is having plans prepared for 16 story, 64 x 265 ft. club and office building, including steam heating system, on Rush and Pearson St. Estimated cost $1,250,000. Schmidt, Garden & Martin, 104 South Michigan Ave., Archts.

Ill., Chicago—Kendall, Lund Amusement Co., 159 North State St., is having plans prepared for 2 story, 125 x 125 ft. store, shop and dance hall building, including steam heating system, on 64th St. and Cottage Grove Ave. Estimated cost $500,000. B. L. Steif, 64 West Randolph St., Archt.

Ill., Chicago—D. S. Klafter, Archt., 64 West Randolph St., is preparing plans for 2 story, 150 x 250 ft. factory, including steam heating system, on Logan Blvd. and Holly Ave., for E. Edelmann & Co. Estimated cost $250,000.

Ill., Chicago—R. G. Schmid & Co., Archts., 154 West Randolph St., is receiving bids for 8 story, 100 x 100 ft. warehouse, including steam heating system, on Desplaines and Van Buren Sts., for Bradner Smith & Co., 175 West Monroe St. Estimated cost $300,000.

Ill., Rantoul—Office of Constr. Quartermaster, Chanute Field, will receive bids until July 10 for construction of boiler house and heating system.

Ill., South Chicago (Chicago P. O.)—South End Hospital Assoc., 11212 South Michigan Ave., plans to build 4 and 5 story, 125 x 149 ft. hospital building, including steam heating system. Estimated cost $300,000. E. E. Hall, 123 West Madison St., Archt.

Ia., Ft. Madison—The Bd. Educ., J. Low, Jr., Secy., will receive bids until July 10 for 3 story, 150 x 178 ft. high school, including steam heating system. Estimated cost $265,000. Owen, Payson & Carswell, American State Bldg., Archts.

Mass., Boston—The Palmer Amusement Co., c/o A. H. Bowditch, Archt., 44 Bromfield St., plans to build 3 story theater on Columbus Ave. Estimated cost $500,000.

Mass., Boston—The U. S. Treasury Dept., Office of Superv., Archt., Wash., D. C., received bids for construction of additional barracks, power house and mechanical equipment at the U. S. Quarantine Station here, from M. Seretto, 3 Tremont Row, $142,500. A. MacDonald & Son, 79 Milk St., $161,616. O. W. Lindberg & Co., South River, N. J., $159,000.

Mass., Dorchester (Boston P. O.)—The City Schoolhouse Dept., 1009 City Hall, plans to build 16 room school on Blue Hill Ave., also 20 room grammar school in the Mather District. Estimated cost $320,000 and $450,000 respectively. Architect not selected.

Mass., East Boston (Boston P. O.)—The City, Schoolhouse Dept., 1009 City Hall, plans grammar school in the Emerson District. Estimated cost $475,000. Architect not selected.

Mich., Winona—The Pampa Land Co. plans to install 150 hp. Corliss engine. Cahill & Douglas, 217 West Water St., Milwaukee, Wis., Engrs.

Minn., Ely—The Minnesota Utilities Co., R. M. Hesketh, Secy., Eveleth, plans a hydro electric development, 5 miles east of here, to develop 12,000 hp. to include dam and large power plant on Falls Lake, etc. Estimated cost $1,750,000.

Minn., Grand Rapids—The Bd. Educ., H. J. Snider, Clk., will receive bids until July 7 for 3 story, 87 x 182 ft. senior high school, including steam heating system. Estimated cost $250,000. Holstead & Sullivan, 607 Palladie Bldg., Duluth, Archts. and Engrs.

Minn., International Falls—The Bd. of Educ., F. E. Patterson Clk., will receive bids until July 6 for 2 story, 100 x 250 ft. high school, including steam heating system. Estimated cost $250,000. Tyrie & Chapman, 1200 Second Ave. and South Minneapolis, Archts. Noted Jan. 24.

Miss., Hazelhurst—W. H. Emerson, Agt., is receiving quotations on refrigeration machinery and equipment for 25 ton ice plant.

Neb., Thedford—The village, J. Figard, Secy., plans new waterworks system, including pumping station and water mains. $20,000 bonds sold for the project.

N. J., Passaic—St. Mary's Hospital, Pennington Ave., is having preliminary plans prepared for 5 story addition to hospital. Estimated cost $300,000. Crow, Lewis & Wick, 200 5th Ave., New York, Engrs. and Archts.

N. J., Trenton—The Public Service Electric Co., Newark, plans to build addition to sub-electric station on North Olden Ave. and install additional machinery. Estimated cost, exclusive of machinery, $20,000. Private plans.

N. Y., Buffalo—S. A. Anderson, County Treas., 11 City and County Hall, will receive bids until June 29 for furnishing a steam turbine driven return line vacuum and large air pump, for 106th Field Artillery, N. Y. N. G., Masten St.

N. Y., Dunkirk—The Romer Axe & Tool Co., 805 Main St., plans to install electric power; will use 75 to 90 hp. increasing to 200 hp. with 440 voltage. D. W. Lathrop, Pres.

N. Y., New York—Starrett & Van Vleck, Archts, and Engrs., 8 West 40th St., will receive bids until July 5 for 9 story store building on 5th Ave. and 50th St., for Saks & Co., Broadway and 33rd St. Estimated cost $2,000,000. Noted July 5, 1921.

N. Y., Utica—The Faxton Hospital Assn., Sunset Ave., will soon award the contract for hospital building on Newell St. York & Sawyer, 50 East 41st St., New York, Engrs. and Archts.

N. C., Charlotte—W. L. Stoddart, Archt. and Engr., 9 East 40th St., New York, will receive bids until July 5 for 12 story hotel on West Trade St., for the Citizens' Hotel Co., here. Estimated cost $1,000,000. Noted June 13.

N. C., Morganton—The town, O. B. Lackey, Mgr., will receive bids until June 30 for gravity water system and extension to distribution system. $250,000 bonds will be sold for project.

N. C., Rutherfordton—The Peoples Ice & Fuel Co., R. L. Taylor, Pres., plans the construction of ice manufacturing plant, 15 tons per day capacity. Estimated cost $15,000, including machinery. Prices wanted on machinery and equipment. Private plans.

Ohio, Cleveland—The city, Purchasing Dept., City Hall, received bids for 1,400 hp. boiler and superheater from the Springfield Boiler Co., $31,203, D. Connelley Boiler Co., Ivanhoe Rd. $33,617. Noted June 20.

Ohio, Painesville—The city, R. B. Wyman, Mgr., is having preliminary plans prepared for addition to electric light plant, including one 1,500 kw. turbine. Estimated cost $50,000. Hadlow & Hick, Finance Bldg., Cleveland, Engrs. and Archts.

Okla., Wewoka—The Bd. of Trustees will soon award the contract for improvements to waterworks, consisting of two 250,000 gal. per day rapid and mechanical filters, high and low duty pump station, repairing and raising present dam, intake, etc. Benham Engineering Co., 512 Gumbel Bldg., Engrs.

Pa., McKeesport—T. B. & L. Wolfe, Archts., Century Bldg., Pittsburg, will receive bids until July 10 for 2 story, 90 x 275 ft. high school on Tin Plate Hill for the Bd. of Educ. Estimated cost $300,000.

Pa., Phila.—F. H. Caven, Dir., Pub. Wks., City Hall, will receive bids until June 29 for 2 story, 39 x 138 ft. administration buildings, including steam heating systems, at Byeberry Farms for Dept. Pub. Health. Estimated cost $600,000. P. H. Johnson, Presser Bldg., Archt.

Pa., Williamsport—The John Peters Packing Co., 1320 East Third St., plans 4 story 68 x 70 ft. addition to packing plant on East Third St. C. B. Comstock, 110 West 40th St., New York, Engr. Prices wanted on cold storage and refrigeration machinery.

S. C., Greenville—I. Bacheler, representing stock company, plans to build 7 story hotel. Estimated cost $500,000. G. L. Preacher & Sons, Healy Bldg., Atlanta, Ga., Archts.

S. C., Laurens—W. G. Lancaster is in the market for machinery and equipment for small ice manufacturing plant. New or used.

Tex., Houston—The Texas Supply Co., Loraine & Semmes Sts., is in the market for 72 in. x 18 ft. return tubular boilers, 150 lb. pressure; also all sizes of fire-box boilers.

"TO ECONOMIZE—COCHRANIZE"

For the Heat Balancer

THE value of an accurate record of feed water is now generally appreciated by engineers. It enables then to compute the evaporation per pound of coal and to detect falling off in boiler efficiency, due to inferior coal, bad firing methods, leaky settings or baffles, scale and soot on heating surfaces, etc.

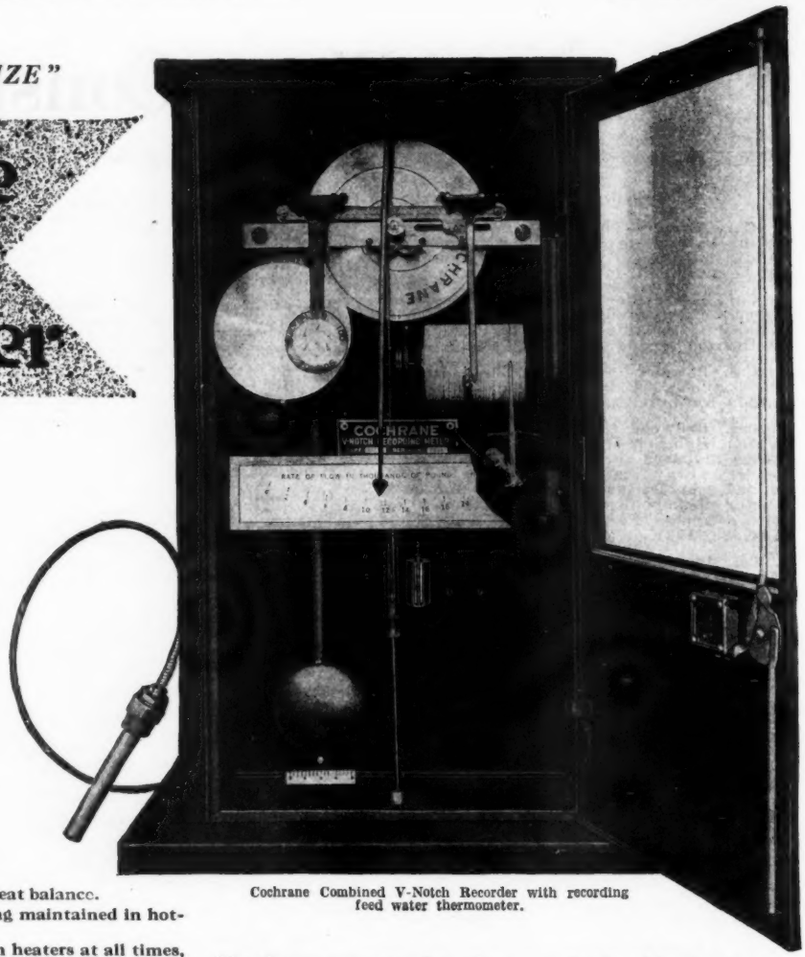
A close record of boiler feed water temperature is equally important, as each 10 deg. Fahr. represents about 1% of fuel. Many boilers are being fed with water 160°, 170° or 180° that ought to be receiving water at 210° F.

A continuous and accurate record of feed water temperature enables the engineer:

(1) **To calculate boiler efficiency and heat balance.**
(2) **To insure that temperature is being maintained in hot-process softeners.**
(3) **To insure full temperature in open heaters at all times, thus securing de-aeration and preventing corrosion in piping, economizers and boilers, and**
(4) **To know whether or not proper attention is being given to heat balancing.**

The Cochrane Combined V-notch Recorder and Recording Thermometer is a further development of the standard Cochrane Recorder using a single clock of the pendulum type.

A thermometer of the expansible fluid type has been added to record temperature on the same chart upon which is recorded the flow over the V-notch.



Cochrane Combined V-Notch Recorder with recording feed water thermometer.

The thermometer consists of a reservoir placed in the storage space of the heater or meter and containing compressed gas, the pressure of which is conveyed through a small capillary tube to a Bourdon gauge, the motion of which is transmitted to a recording pen bearing upon an appropriately ruled part of the chart.

The flow record is entirely separate and distinct from the temperature record; that is, they do not overlap. They are also synchronous, that is, the two pens are in line and rest upon the same hour line, so that the temperature record for any instant is directly above the corresponding flow record for the same instant.

If you are putting in a meter for measuring feed water, the Cochrane combined V-notch Recorder with Recording Feed-water Thermometer will give you all up-to-date improvements and advantages. May we send you further particulars with sample charts? Ask for Bulletin.

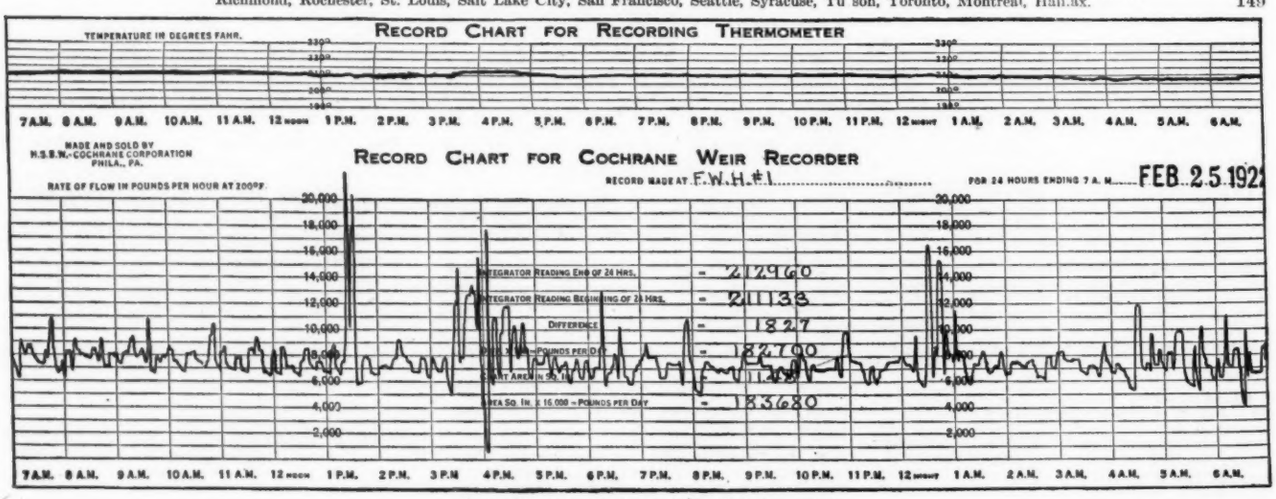
H.S.B.W.-COCHRANE CORPORATION

Formerly Harrison Safety Boiler Works

17th and Clearfield Streets, Philadelphia, Pa.

Also at Atlanta, Baltimore, Birmingham, Boston, Chicago, Cincinnati, Cleveland, Dallas, Denver, Detroit, Greenville, South Carolina; Hazleton, Pa.; Houston, Indianapolis, Kansas City, Little Rock, Los Angeles, Minneapolis, New Orleans, New York, Pittsburgh, Richmond, Rochester, St. Louis, Salt Lake City, San Francisco, Seattle, Syracuse, Tu son, Toronto, Montreal, Halifax.

149


RECORD CHART FOR RECORDING THERMOMETER
TEMPERATURE IN DEGREES FAHR.
7 A.M. 8 A.M. 9 A.M. 10 A.M. 11 A.M. 12 noon 1 P.M. 2 P.M. 3 P.M. 4 P.M. 5 P.M. 6 P.M. 7 P.M. 8 P.M. 9 P.M. 10 P.M. 11 P.M. 12 mdnt 1 A.M. 2 A.M. 3 A.M. 4 A.M. 5 A.M. 6 A.M.
MADE AND SOLD BY H.S.B.W.-COCHRANE CORPORATION PHILA., PA.
RECORD CHART FOR COCHRANE WEIR RECORDER
RATE OF FLOW IN POUNDS PER HOUR AT 200°F.
RECORD MADE AT F.W.H.#1
FOR 24 HOURS ENDING 7 A. M. FEB. 25 1922
INTEGRATOR READING END OF 24 HRS. - 212960
INTEGRATOR READING BEGINNING OF 24 HRS. - 211138
DIFFERENCE - 1822
- 182200
- 183680

Rectangular chart showing both flow and temperature.

Volume 55 June 27, 1922 Number 26

POWER

FRED R. LOW, *Editor*

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BOILERS AND FURNACES

Super-Accuracy 1023

Effects of Boiler Efficiency on Amount of Coal Burned 1025

EDITORIALS

1021, 1022

KNOWS ENOUGH TO ASK QUESTIONS—Heat Insulation Deserves Careful Study—Efficiency of Power Developments at Niagara Falls—Modernizing the Steam Engine.

ELECTRICITY

Fundamentals in Selection and Application of Electric Motors 1007

BY GORDON FOX.

GENERAL MACHINE REQUIREMENTS AND LOADS, characteristics of motors adapted to meet these requirements and general factors influencing motor selection, with brief mention of motor types and the ways in which they may be classified for selection.

Terminating Conduits at the Switchboard 1013

Connecting Alternators in Parallel 1025

Reconnecting an Induction Motor 1025

Drying Out Large Power Transformers 1031

FUEL AND COMBUSTION

Fire Hazards in Plants Using Pulverized Coal 1030

BY L. D. TRACY.

GAS AND OIL POWER

New Opposed-Piston Diesel for Stationary Planes 1020

NEW APPARATUS

Two Helpful Devices for the Steamfitter 1017

Hazleton Centrifugal Pump Primer Exhausts Air from Pump 1020

Condensed Clipping Index of Equipment 1036

PIPING AND VALVES

Clearing Blowoff Pipe with a Water Jet 1024

QUESTIONS AND ANSWERS

1028, 1029

EXPANDING TUBES AND NIPPLES OF WATER-TUBE BOILERS—Submerged Piston and Straightway Pumps—Location of Separator in Refrigerating System—Heating Water in Open Tank—Care of Transformers—Supplementary Governor.

News in the Field of Power 1034

New Plant Construction 1037

REFRIGERATION

Operating an Absorption System 1017

STEAM ENGINES

Strengthening Cracked Flywheel 1024

Silencer on Unaflow Steam Engines 1024

Data from Flow-Meter Charts 1026

Load on Main Bearing 1027

Using Exhaust Energy in Reciprocating Engines 1033

WATER POWER

Queenston-Chippawa Hydro Development Largest in the World 1000

INITIAL INSTALLATION FIVE 55,000-HP. HYDRO-ELECTRIC UNITS; 305 ft. of the 327-ft. head between Lake Erie and Lake Ontario effective on turbines; water carried through concrete-lined canal designed for possible ultimate capacity of 600,000 horsepower.

Supreme Court's Opinion on State Water Rights 1032

Ford Offer Denounced in House and Senate 1032

MISCELLANEOUS

A Practical Way To Test Lubricating Oils for Frictional Losses 1010

BY W. F. OSBORNE.

The Absolute Pressure Gage—Its Construction and Use 1011

BY V. P. GRIFFIN.

Operating Characteristics of Forced-Draft Fans 1012

BY H. E. COREL.

Powergraphs 1014

Cleaning Inspirator Tubes Produced Different Results 1015

Steam Engine Is the Favorite Prime Mover in Massachusetts Industries 1018

Fitting of Keys Causes Loose Pulleys 1023

New York Car Service Impeded by Inferior Coal and Emergency 1032

Directory of Engineering Service 40

Searchlight Section 41-44

Index to Advertisers, Last Page

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Publishers of
Engineering News-Record American Machinist
Power Chemical and Metallurgical Engineering
Coal Age Engineering and Mining Journal-Press
Ingeniería Internacional
Bus Transportation Electric Railway Journal
Electrical World Electrical Merchandising
Journal of Electricity and Western Industry
(Published in San Francisco)
Electrical Review and Industrial Engineer
(Published in Chicago)
American Machinist—European Edition
(Published in London)

The annual subscription rate is $3 in the United States and Canada, Hawaii, the Philippines, Porto Rico, Canal Zone, Cuba, Mexico, Honduras, Nicaragua, Dominican Republic, Salvador, Peru, Colombia, Bolivia, and Shanghai, China. Extra foreign postage, $3 (total, $6, or 25 shillings). Single copy, 15 cents.

Change of Address—When change of address is ordered the new and the old address must be given. Notice must be received at least ten days before the change takes place.

Published Weekly. Entered as Second-Class Matter, Dec. 20, 1910, at the Post Office at New York under the Act of March 3, 1879.

Printed in U. S. A.

Member Audit Bureau of Circulations. Member Associated Business Papers, Inc.

CIRCULATION OF THIS ISSUE, 29,050 COPIES

Moments with the Ad Editor

IF YOU contemplate additions, changes or improvements in your power plant to take care of increased business during the fall and winter season, now is the time to make the necessary changes and installations of new equipment. Do not wait until the rush is upon you; be ready for it. The advertising pages in POWER carry a message of the utmost importance to all power plant men. The manufacturers of the most improved power plant equipment and supplies are here represented and are always ready to send complete detailed information showing how their product can help solve your power plant problems. Are you taking full advantage of the story the advertising pages present to you?

3. Reduction of Friction

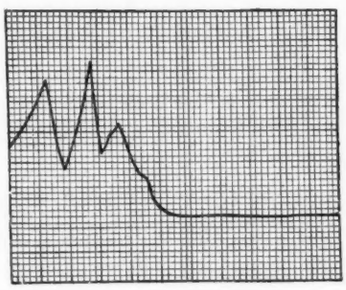
Would you like to reduce your friction load by 25% or better? It is no unusual result with Keystone Grease. In a certain power plant an engine was considered unequal to the work required of it; an efficient lubricating system had been in use. In this particular case the general friction load was reduced by the installation of

KEYSTONE GREASE

"The Master Lubricant"

Power that was formerly wasted is now doing useful work, the lubricating cost is lower, and less attention is required. The contemplated cost of installing a new and larger engine was proved unnecessary and Keystone Grease gets the credit.

Lowering and Stabilizing the Cost Curve



This is No. 3 of 10 Dominant Factors in Lowering and Stabilizing the Cost Curve: — We have a Booklet — Send for it.

KEYSTONE TRADE MARK Reg. U.S. Pat. Off. GREASE

Makes the most efficient mechanical unit more efficient

THE KEYSTONE LUBRICATING CO.

New York
Boston
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Chicago
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St. Louis
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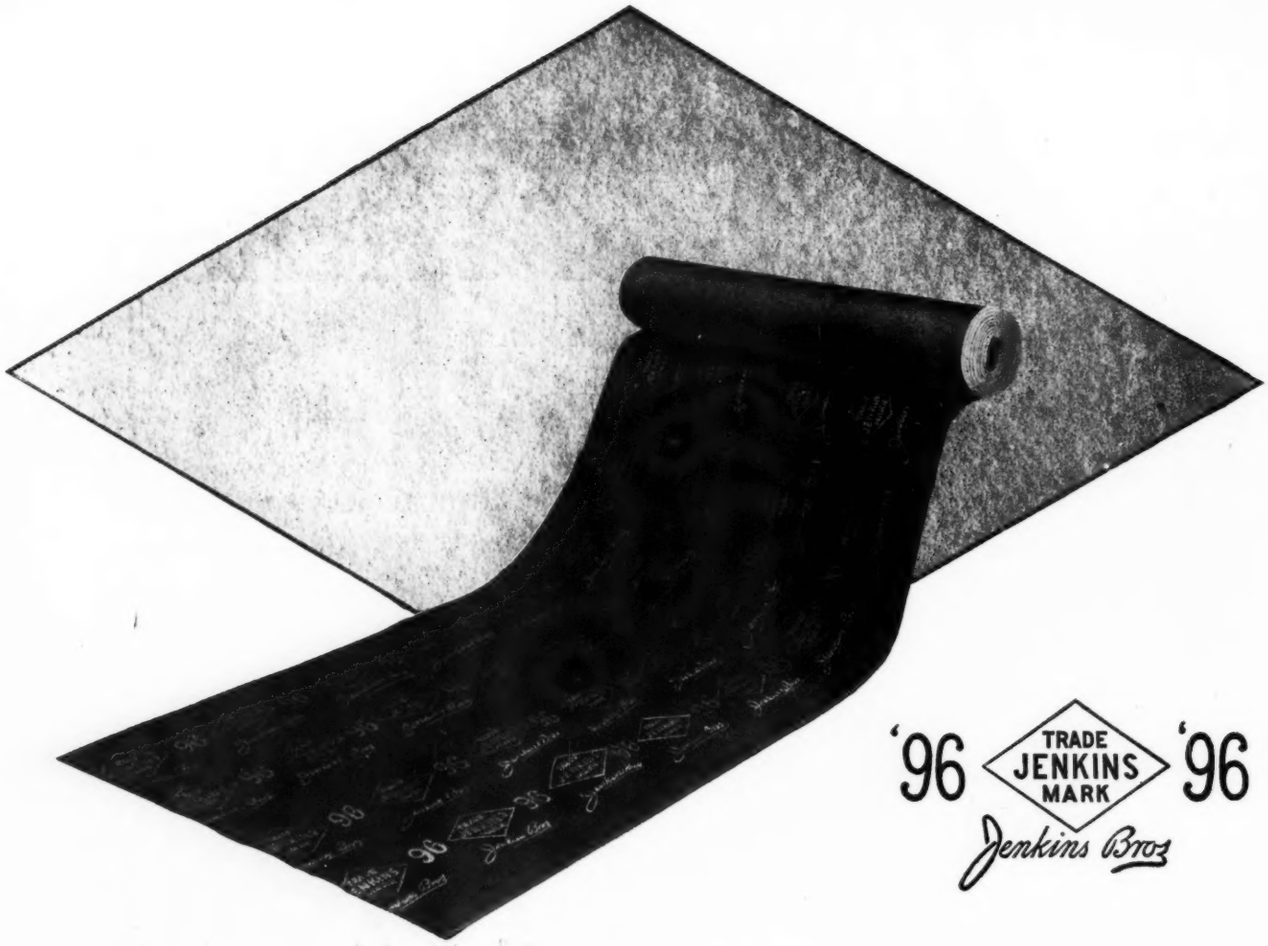


Original unvulcanized sheet packing

JENKINS '96, a black packing, is compounded to form a sheet of great strength and durability, and is recommended for service where saturated steam is used, under all pressures, high and low — equally good for hot or cold water and other liquids.

It is flexible; will bend easily without cracking, and when used in a steam joint is pliable enough to yield readily to any unevenness of flange surfaces, yet strong enough to prevent blowing or squeezing out when under pressure

Jenkins Compressed Asbestos Jointing should be used for superheated, high pressure service

Also included in the Jenkins Line of Mechanical Rubber Goods are *Jenarco*, red sheet packing; *Magnolia* sheet packing; *Oiltite* sheet packing for oil service; Valve Discs; Pump Valves; Gaskets; Tubing; Rings; Washers; and Fuller Balls Ask your supply man for Jenkins Packing and Mechanical Rubber Goods.

Send for latest Catalog.

JENKINS® BROS.

New York Boston Philadelphia Chicago
London Montreal

FACTORIES:
Bridgeport, Conn.; Elizabeth, N. J.; Montreal, Canada

Straining Problems Solved

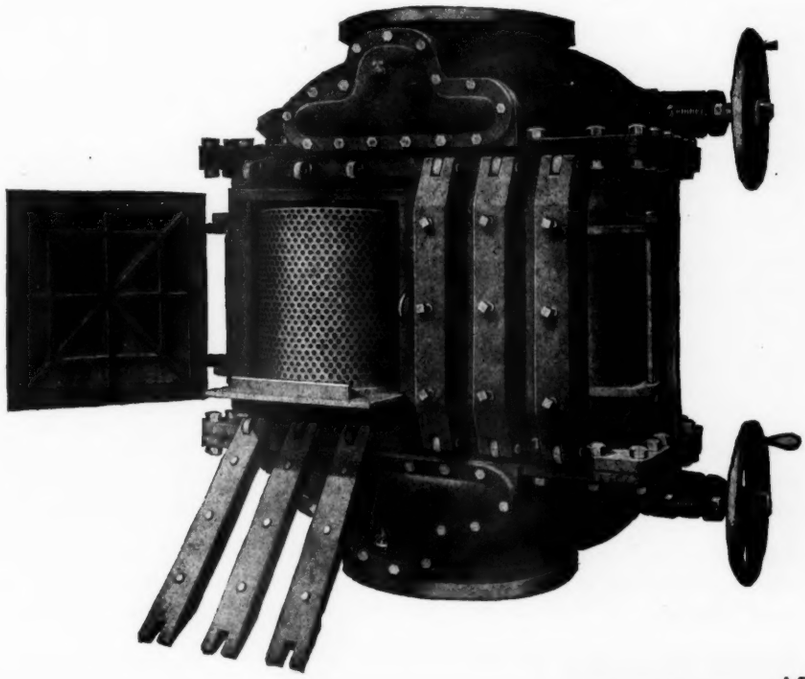
Twin Strainer Advantages

1. Continuity of service. Baskets cleaned without interrupting flow of water.
2. Reliability—nothing to get out of order.
3. Compactness, requires very little space. No foundation needed, simply placed anywhere in pipe line.
4. No moving parts—no attendance except occasional cleaning.
5. Practically no upkeep expense.
6. Easy to install in any position — vertical, horizontal or on an angle.
7. Suction or pressure service.
8. Easy to clean—interior quickly accessible.
9. Large straining area as compared with inlet.
10. Introduces no undue head loss.
11. By using finer mesh, particles of any desired degree of fineness may be removed.
12. No power required for operation, (except large motor operated type).
13. Heavily constructed throughout, equipped with bronze, copper or steel parts, as service requires. Parts exposed to water made of non-corrosive metal.

Made in sizes from 2 in. to 42 in., the Twin Strainer is able to bring its dependable, uninterrupted service, compactness, ease of installation, etc., to the solution of any fluid straining problem.

Use them on individual pumps, or in main water supply lines, for straining water for cooling purposes, turbine gland sealing water, condenser circulating water. They are equally adapted for straining oil, fuel or lubricating, sugar or fruit juices, or any liquid at all.

Fully described in our new Bulletin "A" Ask for a copy.



A-73

Condensers
Air Ejectors
Deaerators
Twin Strainers
Twin Filters
Feed Water Heaters
Steam Separators
Receiver Separators
Blow-Off Valves
Steam Traps

ELLIOTT COMPANY
Pittsburgh, Pa.
GENERAL SALES OFFICES: JEANNETTE, PA.
District Sales and Service Offices in Principal Cities

Often Neglected

All Small Turbines Are Similar But Not Alike in Features That Assure Reliability

—Center Support—to prevent misalignment through expansion and contraction.

—Powerful governor, and emergency overspeed governor.

—Water-sealed glands which prevent packing troubles.

—Heavy cast-iron casing split horizontally for easy inspection.

—Forged steel rotor with electric furnace nickel-steel blades.

—Bronze nozzle and reversing chamber.

Frequently Installed In Inaccessible Places

Naturally, the small auxiliary turbine down in the basement corner will receive less care and attention than the main generating unit on the station floor.

Only by being as nearly foolproof as engineering skill can make them will small turbines meet this requirement.

How then should you select this auxiliary upon which the continuous operation of the entire plant often depends?

Investigate—compare designs—satisfy yourself that the construction refinements are the best, and you will be amply repaid.

Westinghouse Electric & Manufacturing Company
East Pittsburgh, Pa.
Sales Offices in All Principal American Cities

Westinghouse

Coal is the least that a leaky steam trap wastes

By the time power gets up to your coils or machines as steam, it costs far more than at the coal pile, heat unit for heat unit. All along the line you are adding charges of firing, oiling, superintendence and overhead.

So to measure the loss from a leaky steam trap in tons of coal or units of power is not enough. This is a fact which drives home the importance of a steam trap worthy of the name.

"Just a ball—that's all!" A floating ball is the only moving part of the Johns-Manville Steam Trap. No valves, levers or thermostats to get out of order. And the action of this Trap, in preventing loss of steam and discharging air and water, is as sure as it is simple.

Why Johns-Manville Steam Traps do not leak

There is always, in a Johns-Manville Trap, a thin water seal between the steam and the outlet. Here is how this Trap works—and the extreme simplicity of its construction means that it always *does* work.

A hollow ball is the only moving part.

When the entering water raises the ball, the discharge orifice is exposed, and water and air flow out.

When the water level drops, the ball drops. It rolls over the discharge orifice, thus throttling down the outflow and maintaining sufficient water in the Trap to prevent steam leakage.

This action is sure. You can depend on the Johns-Manville Steam Trap to save power and so to help cut your operating costs.

JOHNS-MANVILLE Inc., Madison Ave. at 41st St., N. Y. C.
Branches in 57 Large Cities
For Canada: CANADIAN JOHNS-MANVILLE CO., Ltd., Toronto

JOHNS MANVILLE SERVICE COVERS THE CONTINENT

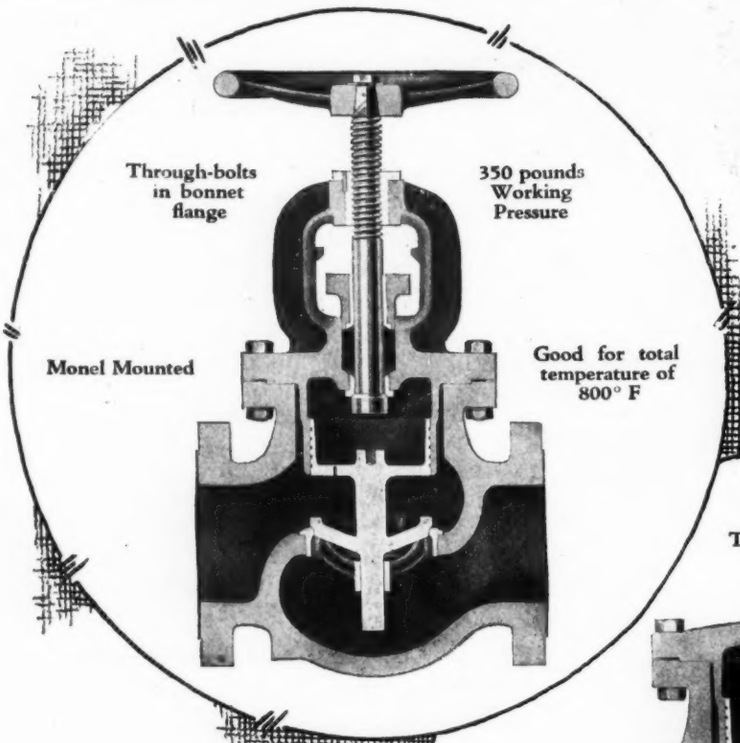
Through—

Asbestos
and its allied products

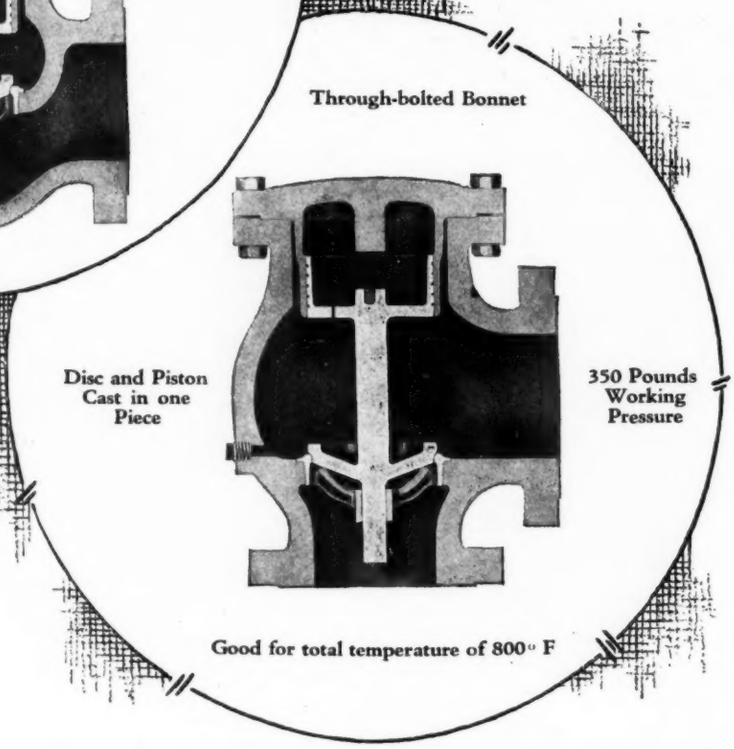
INSULATION *that keeps the heat where it belongs*
CEMENTS *that make boiler walls leak-proof*
ROOFINGS *that cut down fire risks*
PACKINGS *that save power waste*
LININGS *that make brakes safe*
FIRE PREVENTION PRODUCTS

JOHNS-MANVILLE
Power Plant Materials

NELSON



No. 1370—Extra Heavy Steel Non-Return Stop and Check Valve — Globe or Angle—for Superheated Steam.



No. 1690—Extra Heavy Steel-Cushioned Check Valve—Globe or Angle—For Superheated Steam or Water.

NELSON VALVE CO.

ATLANTA—1311 Healey Bldg.
BALTIMORE—8 E. Lombard St.
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CLEVELAND—550 Kirby Bldg.
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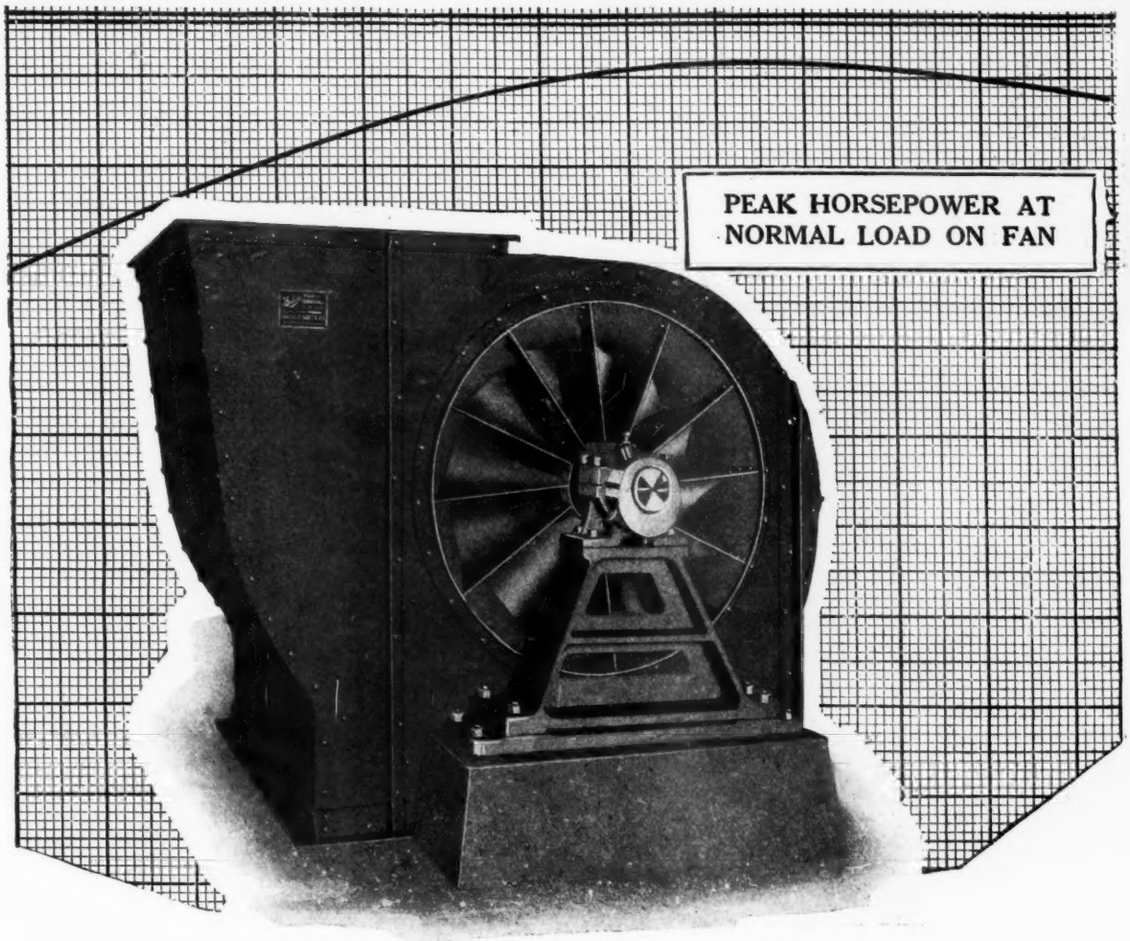


Home Run King on the Fan Field

First: High Efficiency At Normal Load.
Second: High Speed for Direct Connection.
Third: Absolute Protection for Motor.
Home: Utmost Proven Reliability.

"Buffalo"

Forges
Drills
Blowers
Exhaust Fans
Disc Fans
and
Ventilating
Apparatus

You want high efficiency where your longest runs are made—at normal load.

And no gears or belts between fan and driving motor or turbine.

A fan that absolutely protects motor against overloading.

Also one with a long record that proves durability.

You can get *all* these characteristics in but one fan—The Buffalo Turbo Conoidal Stoker Fan that has been adopted by the Ford Motor Company and many others.

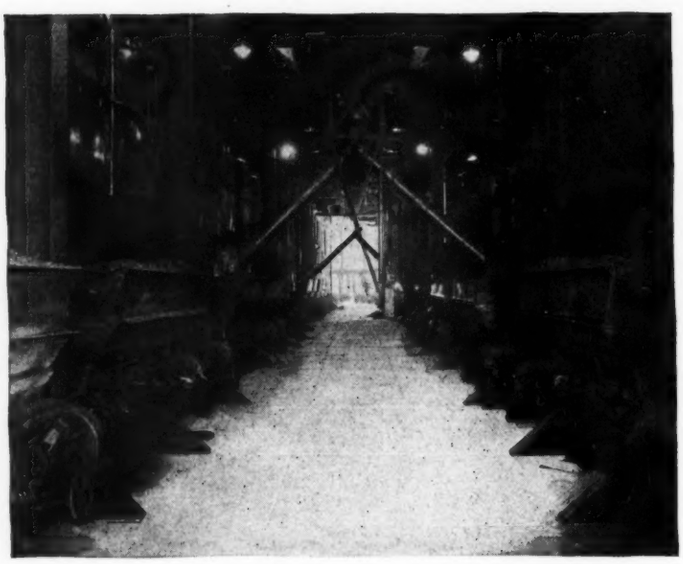
Send for complete data in Catalog No. 62

Buffalo Forge Company
Buffalo, N. Y.

It is interesting to observe the number of instances in which the modern mechanical stoker is following the design of the Taylor Stoker. The Taylor Stoker is the pioneer multiple retort underfeed stoker. It has "made the pace" for combustion apparatus ever since it was introduced.

Watch this page in succeeding issues for the story of the spread of the Taylor Stoker idea.

The Grand Avenue plant (New Haven, Conn.) of United Illuminating Company, an all Taylored station designed by Westcott and Mapes, Inc., Engineers.



Congress Street Station and the new Steel Point Station, both at Bridgeport, are other units of the same system. They, also, are all Taylor Stokered.

United Illuminating Company and their designing engineers—Westcott and Mapes, Inc., have thus far pinned their faith to

The Taylor Stoker

Not Blindly nor without reason, but because

Money can't buy a better stoker

Ask us for information before laying out that boiler room or planning any change-over

American Engineering Company

Philadelphia

Manufactured in Canada by
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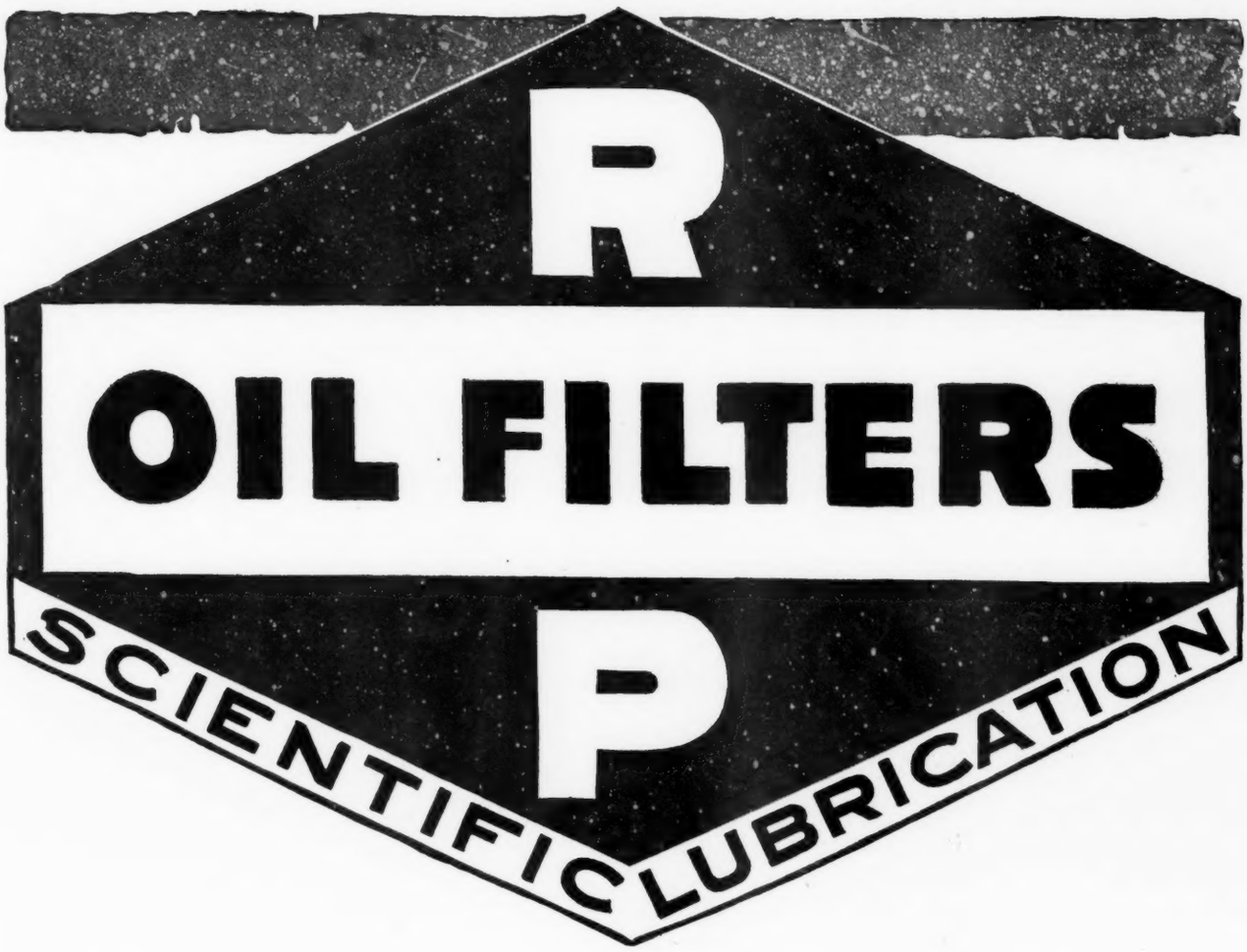
Principal Sales Office: 416 Phillips Place, Montreal, Que.



Whether Your Problem Is One of Lubrication, or Filtration and Reclamation of Lubricating Oil, R-P Engineers Can Solve It, Furnish the Equipment and Guarantee Results

Central Oil and Filtering Systems
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Fuel Oil Strainers for Boilers and Engines
Complete Marine Oiling and Filtering Equipment
Full Line of Oil Pumps

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Sight-Feed Gang and Multiple Oilers
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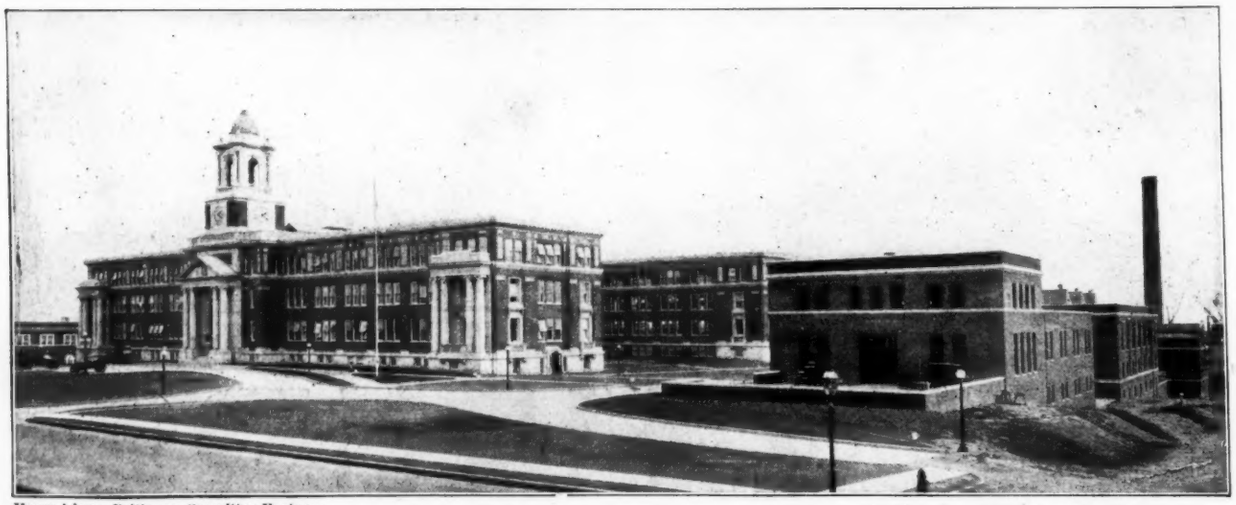
LUBRICATION ENGINEERS AND MANUFACTURERS
FORT WAYNE INDIANA



Henry Adams, Baltimore, Consulting Engineer

In the heart of Baltimore's residential district are the buildings of the Maryland Casualty Co. Dustless ash handling was imperative — the American gave it.

Flying Ash Dust Unnecessary

Flying ash dust is generally associated with ash conveying and most engineers, even where cleanliness is imperative, believe it to be an unavoidable nuisance.

Not where AMERICAN STEAM ASH CONVEYORS are installed. Flying ash dust can be positively eliminated due to our new improved methods. We guarantee dustless operation.

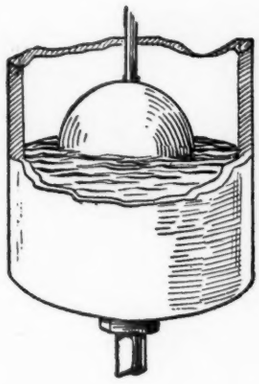
Our booklet, "Cut Ash Handling Costs" describes the AMERICAN STEAM ASH CONVEYOR and lists the guarantees we are prepared to offer. Send for your copy today.

CONVEYORS CORPORATION OF AMERICA
326 West Madison Street
Chicago, Ill.

Western Service Department: 326 West Madison Street, Chicago
Eastern Service Department: 110 West 40th Street, New York

AMERICAN
STEAM ASH CONVEYORS

Hand Feeding or Bobbing Floats



CAN'T

Give You Correct Boiler Feeding

Such methods are antiquated and both are costing their money in the form of needlessly wasted fuel.

Copes Boiler Feed Regulators CAN

Give You Continuous Scientific Feed Control

This modern method of feed control will store excess furnace heat in the boiler water if the load should suddenly drop, and which heat becomes available to assist the furnace in making more steam when the load suddenly increases.

The smooth continuous feed means that you can install smaller size feed piping and that the wear and tear will be lessened due to the absence of shock and water hammer.

Mr. P. Frey, Fuel Engineer of the Lehigh Coal and Navigation Co., Lansing, Pa., in his report to the Garfield Fuel Administration says:

"Automatic feed water regulation is so cheap that it is the best boiler appliance that can be gotten for its worth in money."

A prominent chief engineer wrote:

"It is possible to maintain a more uniform distribution of load over a battery of boilers, also to obtain slightly better efficiency as well as a greater factor of safety with a reliable feed water regulator than by hand regulation."

We invite investigation. Nearly 10,000,000 boiler horsepower are already equipped with the Copes. Over 98% of the largest Central Stations have chosen the Copes for feeding their boilers.

Will you adopt the safe course?

Write For Catalog "A"

COPES

NORTHERN EQUIPMENT CO.

110 WEST 11TH STREET.——.——.ERIE. PENN.

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Croydon, England
Cologne, Germany

COPES

Better

WE are sometimes asked how it is that Combustion Engineering Corporation gives so much better service than the manufacturer of mechanical equipment can usually give.

To some the answer is plain. Most manufacturers have only one type of machine to do a given task, but inasmuch as the coals of the world have each their own individual characteristics, and each plant has its own physical characteristics, our engineers recognized long ago that no one type of stoker could possibly fit any and all conditions.

Our engineers also found that in certain cases powdered fuel was to be desired rather than the mechanical stoker depending on local and physical plant conditions.

INTERNATIONAL COMBUSTION

Combustion Engi

Combustion Engineering Bld

Offices in Principal Cities

Frederick Multiple Retort Stokers
Type E Stokers
Type D Stokers
Type K Stokers
Type H Stokers
Self Contained Stokers

COMBUSTION ENGINEERING CORPORATION NEW YORK

Service

And so we *must know*, and *to know*, we naturally have to have an exceptional engineering organization to analyze what your requirements are when you ask us. When you negotiate a stoker purchase with any concern that has only one machine to offer you naturally expect to have the advantages of that machine pointed out. In our case you are not "sold" a stoker; you "purchase" what your judgment dictates after a full presentation of the facts by an organization that is able to give you ALL the facts freely.

And this is "better service." You have at your command in making your decision the combined brains of an organization that has in its employ specialists in every problem that your plant may present, which is one of the fundamental reasons for the exceptional sales of our products, even in dull times.

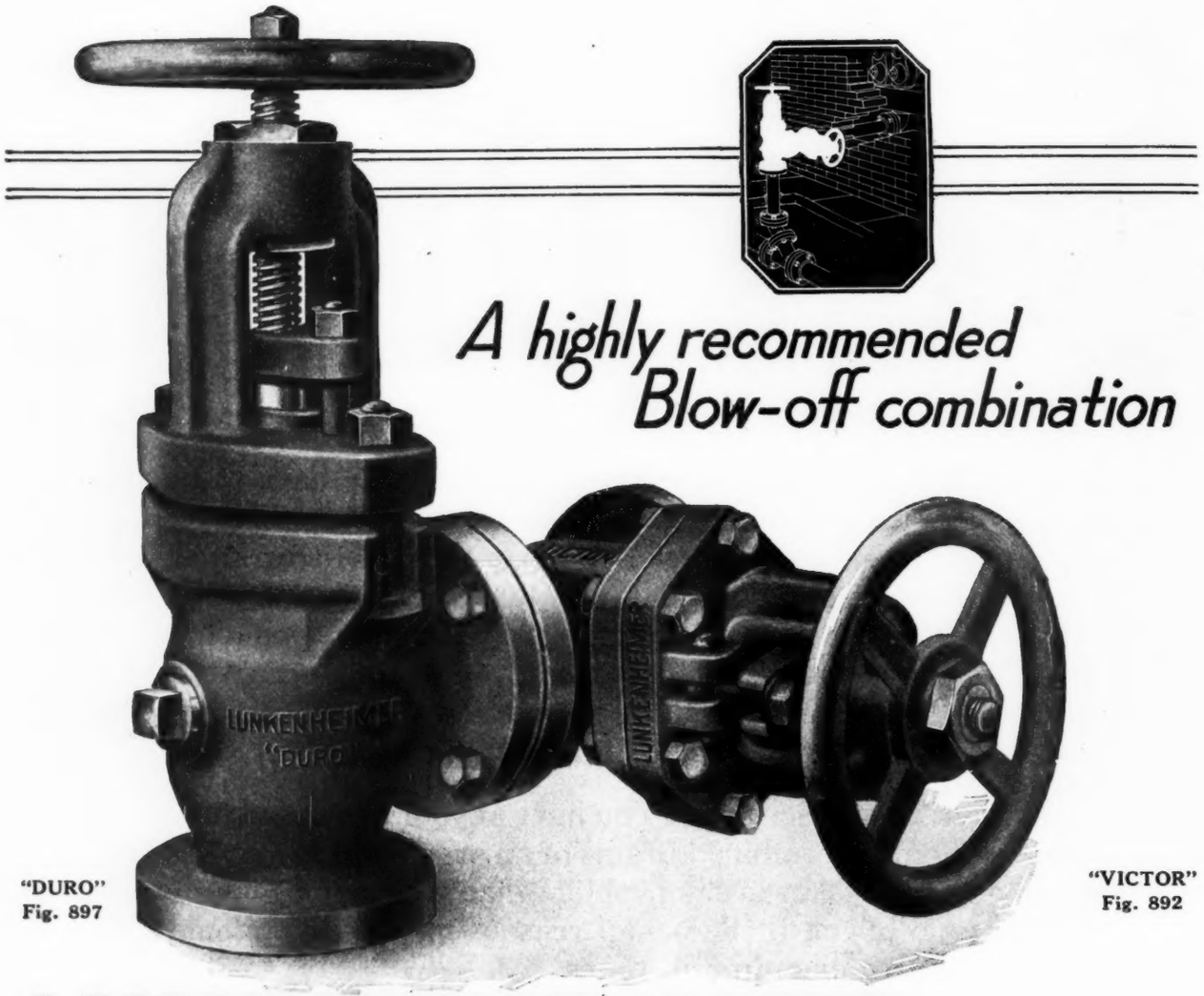
ENGINEERING CORPORATION

ineering Corporation

43 Broad Street New York City

Throughout the World

Lopulco Pulverized Fuel Systems
Coxe Stokers
Grieve Grates
Air Heaters
CEC Tube Scraping Device
Combusco Water Seal Conveyors



"DURO"
Fig. 897

"VICTOR"
Fig. 892

A highly recommended Blow-off combination

LUNKENHEIMER
Blow-off Valves

Remain tight in service, prevent waste through boiler blow-off lines, and thereby turn to a profit the losses caused by leakage which frequently occurs at this point.

In Lunkenheimer Blow-Off Valves the water is released gradually due to the peculiar construction of the seat and disc. This virtually makes them safety devices since they eliminate the dangers incident to undue agitation within the boiler or severe shock in the discharge line which results when blow-off Valves are opened suddenly.

Lunkenheimer design and construction reduces wear to a minimum. When wear does appear the repair of the parts affected is easily accomplished and when a part is worn beyond repair it can be renewed.

The installation of Lunkenheimer Blow-Off Valves is the solution of your boiler blow-off problem. Why not get the facts first hand?

Descriptive literature on request.

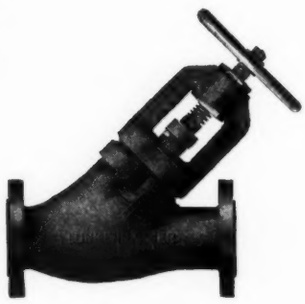


Fig. 1352
Straightway or
Y Pattern

THE LUNKENHEIMER CO.
"QUALITY"

Largest Manufacturers of High Grade Engineering Specialties in the world.

CINCINNATI, U. S. A.

New York **Boston**
Chicago **London**

Export Department:
129-135 Lafayette Street, N. Y.

1606-24-42

"America's Best since 1862"

Harrington Stokers burn every kind of coal—insure high efficiencies over a wide range of capacities—and operate with minimum maintenance costs.

Where Power is the Product

CENTRAL stations have one object—to deliver power at the greatest profit. Greater power at lower cost is their whole goal.

Whatever central stations practice is worth heeding by other concerns with a power plant—whether they make shoes, soap or soup.

Central stations are turning more and more to the Harrington Stoker and this fact holds a lesson of prime importance to industrial executives.

One of the largest central stations, The Cleveland Electric Illuminating Co. placed an order for 9 Harrington Stokers in May 1920. After thoroughly testing and comparing the Harrington Stokers with other stokers in the same plant, they ordered 18 additional Harringtons.

Central stations and manufacturers alike are lowering fuel costs and are improving plant efficiency with Harrington Stokers.

The Harrington is the only stoker that will burn every kind of coal under any plant condition. The unique grate construction of the Harrington makes it non-sifting and automatically self-cleaning. The Harrington has many other features that will interest you.

Write for ***"Twelve Fuel Facts"***.

THE UNITED MACHINE & MFG. CO.
CANTON OHIO
DEPT. M

Branches

New York, Philadelphia, Pittsburgh, Atlanta, Cleveland, Chicago, Detroit, Seattle, Saint Paul, Columbus, Kansas City

THE HARRINGTON STOKER

FORCED DRAFT *With*

Dependability is combined with economy in the new Green Forced Draft Chain Grate Stoker.

In stoker and furnace are designs and features which insure dependability with performance that results in cheapest steam:

Green Forced Draft Chain Grate Stokers—

Give natural draft performance up to 150 per cent of boiler rating. The high peaks and continuous high ratings of the forced draft load are always available.

Have the fuel bed surrounded on its three active sides with water cooled members which protect brickwork, improve combustion and add to capacity.

Are a new departure in air pressures involved. Compartment areas are large. Air pressures are low.

This stoker will burn all free burning Bituminous coals and Coke Braize.

Green Chain

DEPENDABILITY

We are demonstrating in this stoker at maximum ratings:

Operation with no part overheated or strained;

Cold ash pits;

Continuous discharge of dead ash;

A tight stoker setting and no gases or air blowing out at front, sides or rear;

A design which gives free firing aisles and accessibility to all parts of the stoker;

Ease and simplicity of operation;

High combustion efficiency.

The Green Forced Draft Chain Grate Stoker takes that common sense balance of Efficiency, Capacity and Maintenance—peculiar to Green natural draft performance—into the forced draft field.

Green Engineers will be glad to discuss this stoker with you. There is no obligation involved on your part.

GREEN ENGINEERING COMPANY

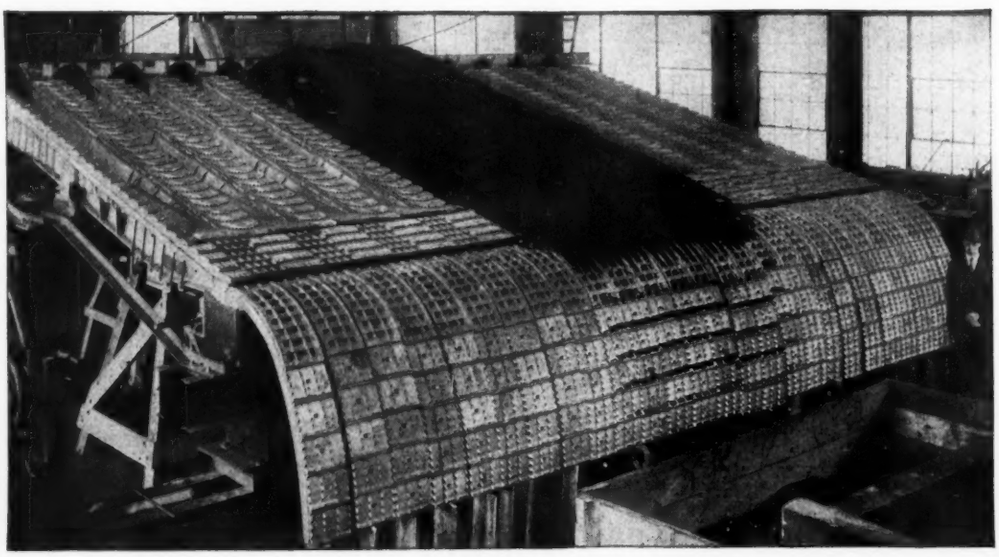
40 Kennedy Avenue East Chicago, Indiana

Grate Stokers

FORCED DRAFT
NATURAL DRAFT
ASH CONVEYORS
CAST-IRON HOPPERS
SEALFLEX ARCHES
PRESSURE WATERBACKS
FUEL RETARDERS

The STOKER with the CONVEYOR TUYERES

Modern central stations require large boiler units operated at high capacity with maximum efficiency. To meet these requirements the Sanford Riley Stoker Company is now building stokers of any length desired up to a furnace depth of approximately 20 feet. This design is known as the Riley Super Stoker and the first installation has been in successful operation since February, 1922.



Shop view of stoker

Successful feeding of coal through a furnace 20′ long is made possible in a simple manner by the Riley Conveyor Tuyeres. The tuyeres or moving grates on the Riley Stoker perform two separate functions.

1. They admit air at the proper place in the fuel bed.

2. They convey the coal from the entrance of the furnace uniformly towards the dump at any rate desired independent of the coal feed.

The photograph of the super stoker above shows the even distribution of coal over the entire surface from front to rear.

The simplicity of the mechanism is apparent, no extra plungers nor complicated feeding devices are required even though the coal is carried this long distance.

Working under the fuel bed and regulated from outside the furnace, these conveyor tuyeres perform their double duty in an easy and satisfactory manner.

The Sanford Riley Stoker Company is now prepared to equip new Riley Stokers with coal agitators licensed under the Negus-Tiffany Patents.

TRADE MARK Rx REGISTERED

SANFORD RILEY STOKER CO.

WORCESTER, MASS.

Owners of MURPHY IRON WORKS, Detroit, Mich.

STOKER MANUFACTURERS ASSOCIATION SMA

MURPHY AUTOMATIC FURNACES

BRANCHES

BOSTON NEW YORK PHILADELPHIA PITTSBURGH
BUFFALO CLEVELAND CINCINNATI CHICAGO

AGENTS

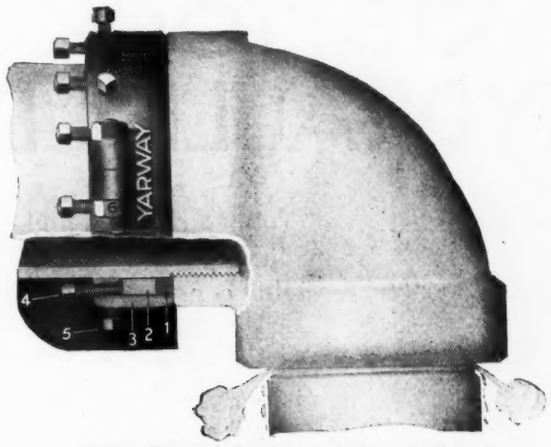
Beeson Machinery Co. Kansas City
Stearns-Roger Mfg. Co., Denver, Col.
Robinson, Cary & Sands, St. Paul, Minn.

Stop Leaks Quickly and Permanently—at Small Cost

Leaky pipe lines are mighty expensive. One little ⅛-inch leak in a steam line under 150 lbs. pressure will leak away in a few months enough money to buy you a complete stock of YARWAY PIPE CLAMPS. YARWAY PIPE CLAMPS will stop nearly any pipe line leak, large or small—stop it completely, permanently, and in a very few minutes.

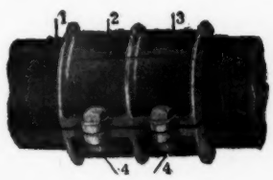
The YARWAY PIPE-JOINT CLAMP stops leaks in threaded joints; the YARWAY HOLTITE PIPE CLAMP stops holes and splits in straight pipe. Either can be applied by any workman.

Send today for list of users and what they say—ask for Bulletin C-805.



Above: Yarway Pipe-Joint Clamp. 1, Ring of packing; 2, follower ring; 3, outside housing; 4, screws to force packing ring against leak; 5, set screws nolding housing to pipe.

Below: Yarway Holtite Pipe Clamp. 1, Packing; 2, split or hole in pipe; 3, metal clamp; 4, tightening bolts.

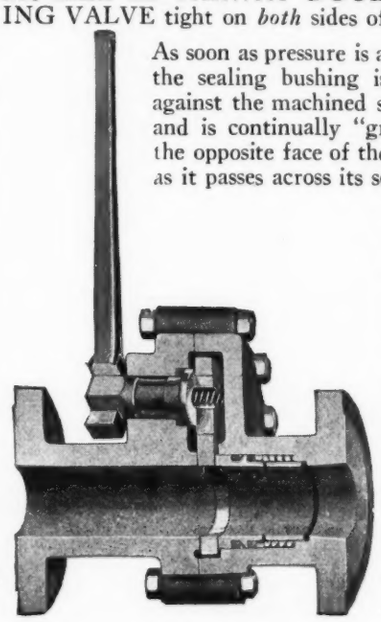


YARWAY

Power Plant Devices

Tight On Both Sides of the Gate

The unusual feature of a sealing bushing on the inlet side makes the YARWAY DOUBLE-TIGHTENING VALVE tight on *both* sides of the gate.

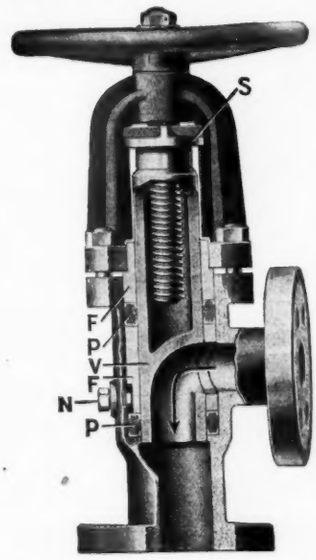


As soon as pressure is applied on the line, the sealing bushing is forced up tight against the machined surface of the gate and is continually "ground in," just as the opposite face of the gate is ground in as it passes across its seat.

This valve is especially adapted for use in tandem with the Yarway Seatless Blow-Off Valve. Installations of this type have been highly successful.

Double Security

The slow-opening plunger type **Yarway Seatless Blow-off Valve** and the lever-operated gate type **Yarway Double-Tightening Valve,** forming the Yarway Tandem, give double security and perfect service on blow-off lines where two valves are required.



It Stays Tight—Over 20,000 Sold

The **Yarway Seatless Blow-off Valve** has no seat or discs to leak—it **lasts** and **stays tight.**

Note the simple design and rugged construction. After valve has closed, shoulder S on plunger V engages the loose follower gland F. A hard turn of hand-wheel then compresses packing P above and below the port, making an absolutely tight valve.

Set screw N prevents turning of gland F when hand-wheel is turned.

Send for your copy of Booklet B-410, containing full details.

YARNALL-WARING CO.

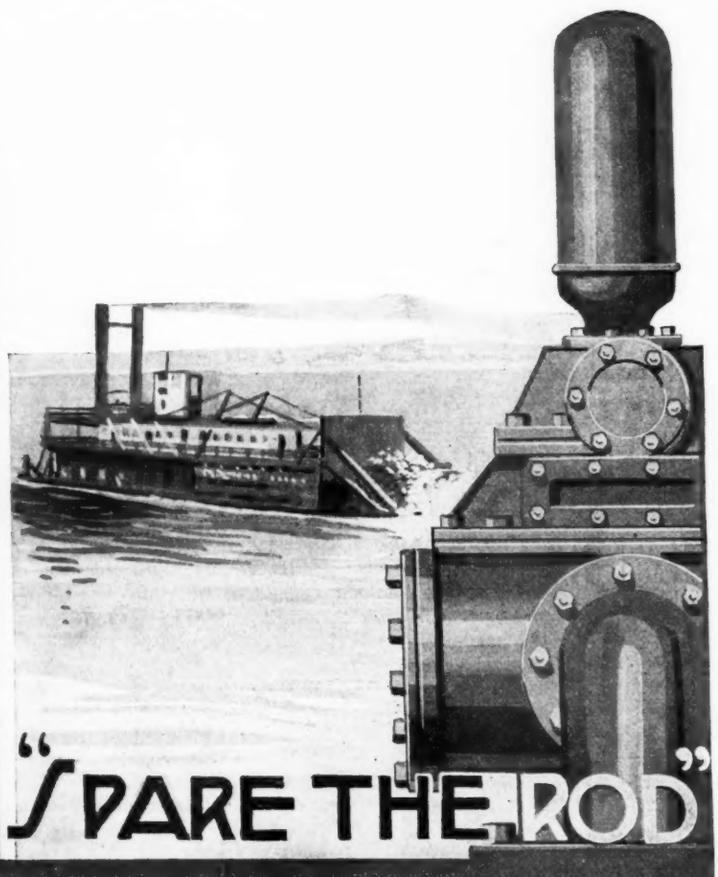
MERMAID AVE. PHILADELPHIA

Garlock Style No. 987 HYDRAULIC DUO PACKING

A combination of rubber cushion and waterproof hydraulic rings. This packing gives excellent service for medium pressures. The reversed cushions make it very effective in handling sandy water, receiving constant lubrication from the waterproof hydraulic rings.

Garlock Hydraulic Duo Packings have been prepared with a thorough understanding of the diverse conditions of hydraulic service.

Among our combinations we have a packing that will solve your problem and succeed where other hydraulic packings have failed. Let us advise you.



"SPARE THE ROD"

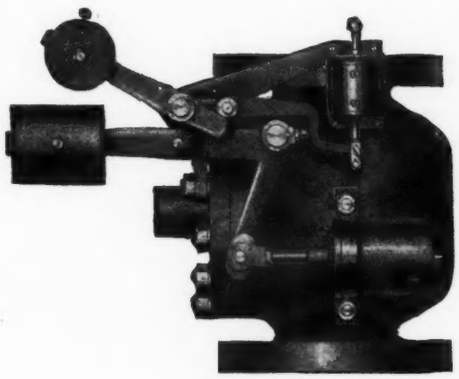
GARLOCK PACKINGS

The Garlock Packing Company
PALMYRA, NEW YORK

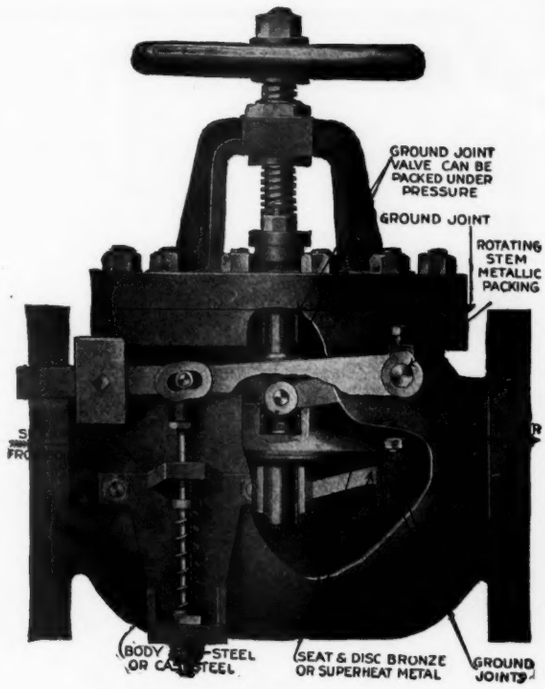
Branches:

New York	St. Louis	Pittsburgh	Birmingham
Chicago	Boston	San Francisco	Hamilton, Ont.
Philadelphia	Cleveland	Denver	

STEAM SAVING SPECIALTIES



Engine Stop


GROUND JOINT VALVE CAN BE PACKED UNDER PRESSURE
GROUND JOINT
ROTATING STEM METALLIC PACKING
STEEL
SEAT & DISC BRONZE OR SUPERHEAT METAL
GROUND JOINTS

Strong Non-Return Stop Valve

Nip Danger In the Bud

Accidents don't happen—they UNWIND. The wise engineer nips danger in the bud—circumvents disaster by eliminating elements of risk.

These dependable automatic safety devices are an absolute protection from the dangers arising from runaway engines and the sudden reversal of steam flow into damaged boilers.

"Strong" Engine Stops, in addition to automatically preventing accidents caused by racing engines, furnish a means for instantly shutting down the engine from a distance in case of trouble or to prevent accidents throughout the mill. They are released by centrifugal force and closed by gravity. Mechanical operation. But an electrical attachment can be added for remote control stations.

The sudden reversal of steam into a damaged boiler brings about condition fraught with menace to man and plant. This danger can be nipped in the bud automatically by placing a "Strong" Non-Return Stop Valve between the main header and the boiler. Should a reduction in pressure take place in the boiler as the result of a blown tube, for instance, the valve closes and the boiler is shut out of service. Outside control makes it absolutely dependable.

Mail the coupon for catalog describing "Strong" Specialties for safety and steam saving.

The Strong, Carlisle & Hammond Co.
Cleveland, Ohio

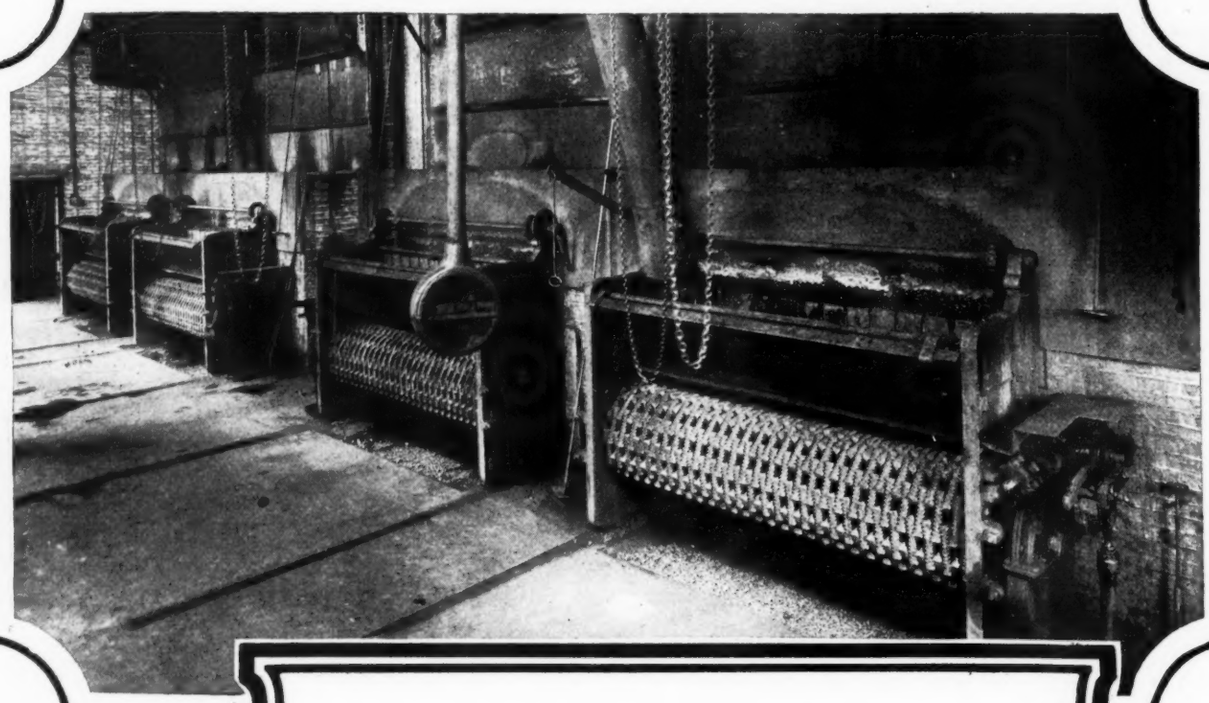
The Strong, Carlisle & Hammond Co., Cleveland, Ohio
Gentlemen: Please send me a copy of your latest Catalog No. 18-P at your earliest convenience.

....1922

Name.....

Address.....

6-27-22



Don't slight the problem of cutting down for light loads—

You can't control the load. Can you control your stokers? If not, you waste fuel when carrying light loads.

There are two ways of reducing a fire when the load demand drops to say 50% of rating.

One way, the usual way, is by reducing the draft. A reduced draft means a dull fire and consequently a low CO_2. This is the wasteful way.

The efficient way is known to every operator of Illinois Chain Grate Stokers. The air control dampers enable the engineer to reduce or stop off the air supply from the rear section of the grate. This is equivalent to actually reducing the size of the fire. The fire is merely smaller, but as bright and snappy as when carrying an overload.

This widely praised ability of Illinois Stokers to maintain highest combustion efficiency at high, low and intermediate boiler ratings is only one of the many merits of Illinois Chain Grate Stokers.

Type A National Draft.
Type G Forced Draft.

Permit us to explain the many other evidences of Illinois progressiveness.

Illinois Stoker Co., 104 W. 7th St., Alton, Ill.

CHAIN GRATE ADVANTAGES—

The basic principle of any chain grate stoker insures:

—total freedom from clinker trouble.
—lowest labor costs.
—absence of steam consuming auxiliaries for removing clinkers.

Illinois Stokers have these additional advantages:

—forced draft for overloads.
—dampered air control.
—mechanical ignition for burning high moisture and low volatile coals.

ILLINOIS CHAIN GRATE STOKERS

Chicago: Ernest E. Lee Co., 115 S. Dearborn Street
Kansas City: J. F. Pritchard & Co., 419 Reliance Bldg.
Minneapolis: H. R. N. Johnson, 917 A Marquette Ave.
New York: H. G. Meissner, 141 Broadway
Indianapolis: R. H. Bennett, 305 Merchant's Bank Bldg.

"We are installing another unit, double the size of this, of the same manufacture."

Mr. R. T. Price, Superintendent of the Elk River Coal and Lumber Company's plant at Widen, West Virginia, also says concerning their Ingersoll-Rand Counter-Current Barometric Condenser—

"This unit has been in continuous operation since the early part of 1917, except for a few hours' shutdown each Sunday. It has always given entire satisfaction."

The service which this plant is giving is typical of I-R Barometric Condensers. Their counter-current operating principles enable them to maintain a uniformly high vacuum even under the most severe operating conditions.

Ingersoll-Rand Company
11 Broadway, New York City
Offices Everywhere

Write for descriptive literature

Ingersoll-Rand Counter-Current Barometric Condensing Plants consist of the Condenser proper, an I-R Dry Vacuum Pump and a Cameron cold water injection pump.

82-BC

Ingersoll-Rand

Low Level Multi-Jet Barometric and Surface Condensers

Now~IT IS FUEL ECONOMY

VIII

MANY firms who operate power plants—even of small size—or who use steam for a heating system or for special processes could make themselves a gift of thousands of dollars a year by practical changes in the operation of their boiler and power plants which would involve but minor additions to their equipment.

It is no theory, but a substantial fact, that the power plant owner pays for the fuel and power saving equipment he does not have—pays for it in higher production costs, in fuel, in labor, in maintenance and in a myriad of other outlays that sap his profits.

The use of a number of boiler room accessories of simple character can effect economies of substantial magnitude that will increase the net revenue.

There are ways to measure the output of the power plant against its cost of operation. Not by a host of intricate formulae and delicate instruments, but by practical means understandable to layman or financial executive as well as to the engineer.

In "The Boiler Room and the Bank Balance" we have gone further in the description of power plant problems. If you would like to see this book and learn how economies have been obtained by McClave Combustion Systems in thousands of successful plants, write for a copy.

McClave GRATES STOKERS STEAM BLOWERS CB

McCLAVE-BROOKS COMPANY

Makers of the famous McClave Grates Since 1883

Scranton, Pennsylvania

BRANCH OFFICES:

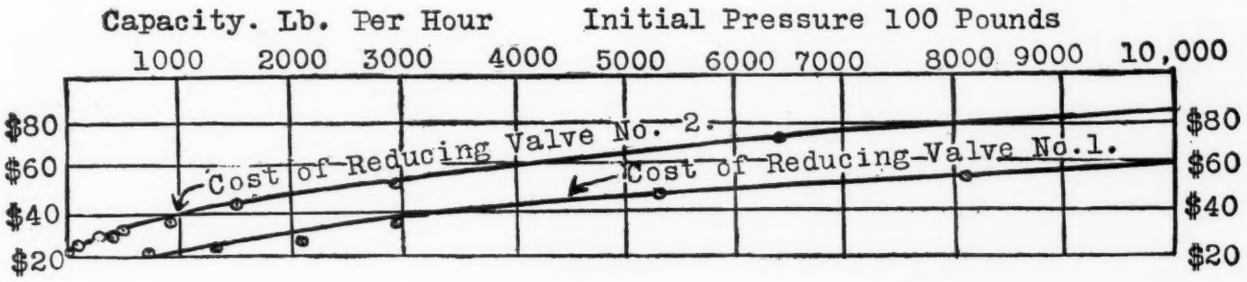
New York Philadelphia Boston Detroit Chicago Greenville, S. C. Kansas City
St. Louis Jackson, Miss. Pittsburgh Cincinnati Syracuse Dallas Salt Lake City
St. Paul Owensboro, Ky.

Your engineer will confirm these statements.

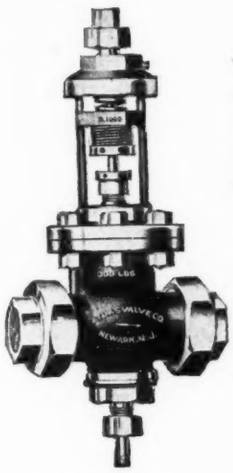
McClave COMBUSTION SYSTEMS *for greater economy*

These Curves Tell Everything

—They prove that it pays to buy reducing valves *scientifically*—

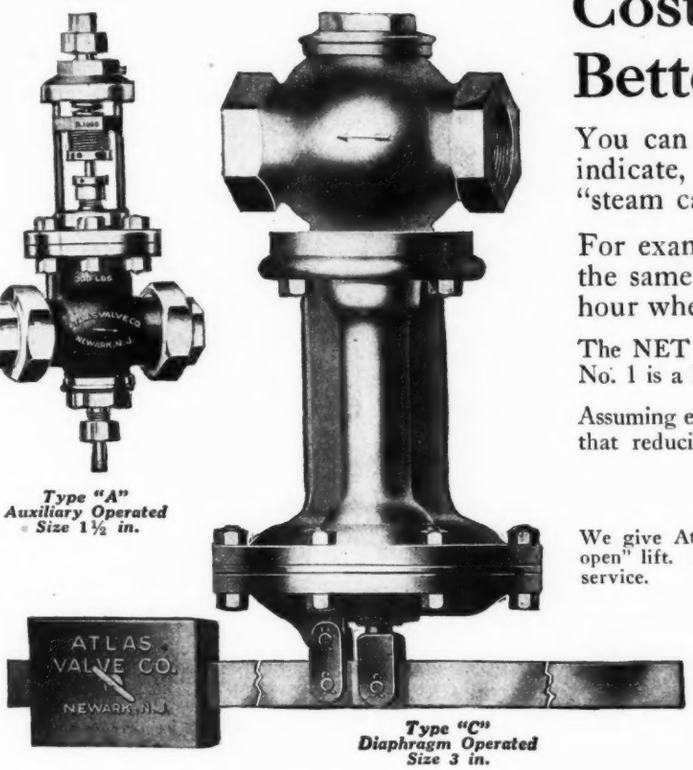


No. 1



Type "A"
Auxiliary Operated
Size 1½ in.

No. 2



Type "C"
Diaphragm Operated
Size 3 in.

Same Capacity Costs Less Better Service

You can save much money, as the above curves indicate, by purchasing reducing valves on a "steam capacity basis."

For example, valve No. 1, shown at the left, has the same capacity as valve No. 2 — 2930 lb. per hour when reducing steam from 100 lb. to 5 lb.

The NET price of No. 1 is $37.40. No. 2 costs $60. Yet No. 1 is a BETTER valve in every way.

Assuming equal steam flow velocity through the seats, it is plain that reducing valve capacity depends upon these two factors:

1—diam. of valve seat;
2—lift of valve.

We give Atlas type "A" valves the RIGHT diameter and a "wide open" lift. Hence the smaller size, the lower cost, and the BETTER service.

Reducing valve capacity is limited to the power of the control mechanism to hold the valve in operation against the impact of the steam on the seats. Atlas high lift capacity valves are controlled by a powerful piston. Wire drawing and consequent valve wear are avoided. Chattering is eliminated.

Why not be economical? Why not select valves scientifically? Our new hand book tells how—explains all. Use the coupon below and get YOUR copy.

ATLAS VALVE COMPANY, NEWARK, N. J.

FILL IN, TEAR OFF, AND MAIL

OUR NEW HAND BOOK

simplifies the reducing valve problem. It tells how to select the best and *most economical* valve. This coupon will bring you a copy. Simply fill in and mail. You will not be obligated in any way.

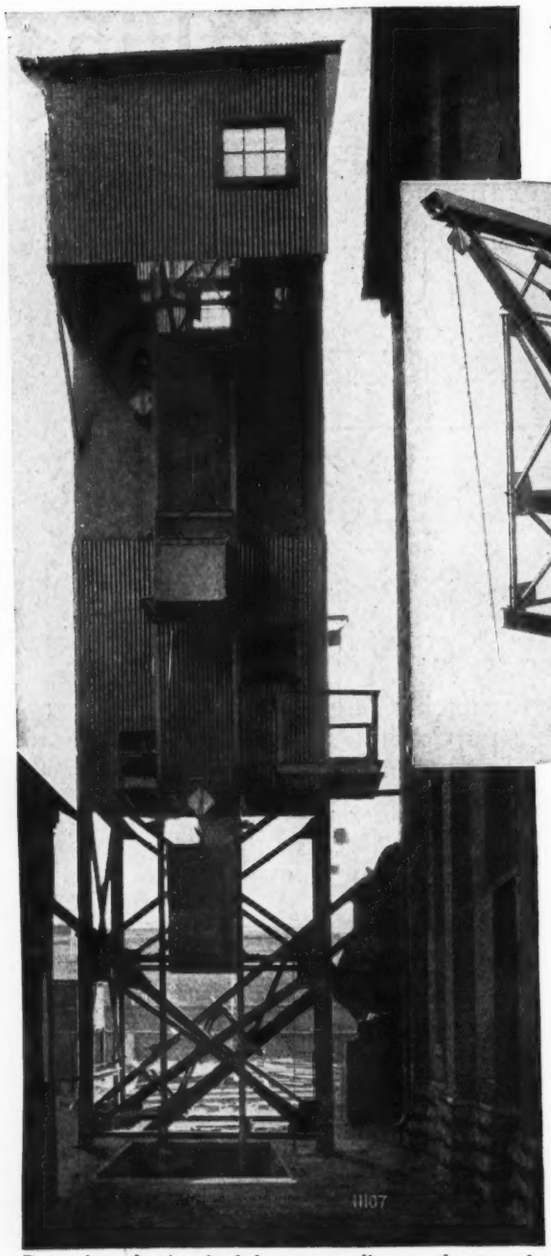
Name..... *Firm*.....

Address.....

.....

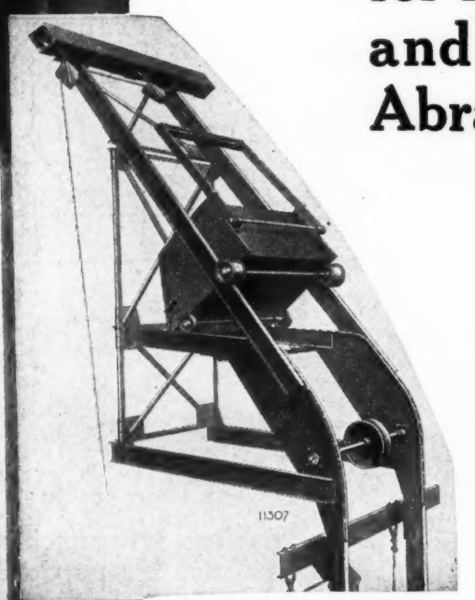
ATLAS VALVE COMPANY
REGULATING VALVES FOR EVERY SERVICE
289 South St., Newark, N. J.

ATLAS Type "A" Valve—same capacity—smaller seat—wide open—our Hand Book tells why.



Rear view showing loaded car ascending to the top of Storage Bin

A view in the basement of a Jeffrey Skip Hoist installation. The movement of the vertical skip car is controlled by an electric push button conveniently located for the operator at the loading point.



Headframe of the Jeffrey Standard Skip Hoist with bucket in dumping position.

Especially Adapted for Handling Ashes and Other Highly Abrasive Materials

Material handled with the Jeffrey Skip Hoist does not come in contact with the operating mechanism, the wear being on the plainly constructed carrying car, and when this is worn out the replacement is inexpensive.

JEFFREY

Standard Skip Hoist

is simple in construction, of low initial and maintenance cost.

It is inexpensive to operate as it is in service only when actually carrying a load.

Its wide-open-mouth Skip buckets permit the carrying of large clinkers without previous crushing.

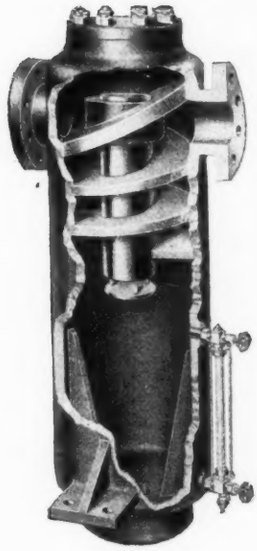
Made in two standard sizes using a 27 cubic foot and 40 cubic foot bucket.

Catalog No. 271-A gives full particulars.

Jeffrey complete Coal and Ashes Handling Equipment includes Track Hoppers; Reciprocating Plate Feeders; Bucket Elevators; Crushers; Conveyers of the Bucket, Pan, Scraper, Steel Apron, Spiral, Belt, Drag Chain and other types; Traveling Weigh Hoppers; Portable Bucket Loaders; Portable Belt Conveyers; Portable Car Unloaders, Etc.

The Jeffrey Manufacturing Co.
932-99 North Fourth Street, Columbus, Ohio

Do You Get Dry Steam?



It all depends on the kind of separators that are installed in your pipe lines.

THE NEW STRATTON SEPARATOR

delivers steam that is positively dry.

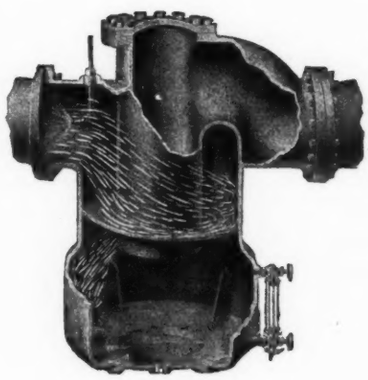
It is a redesign of the Stratton Separator which has established a world-wide reputation for reliability by its performance record in thousands of plants.

The helical path has been lengthened considerably to increase the centrifugal action. A spatter cap has been added to the outlet pipe.

Be sure to specify the New Stratton Separator.

Ask for Form Sheet No. 177, containing dimension tables and other data.

Are Your Heating Coils, Heaters, Boiler Tubes, Etc., Lined With Oil?



This condition is a menace to safety in the boiler room and results in much needless fuel loss due to the greatly reduced heat transmission through the insulating film of oil.

Clean exhaust steam is the remedy. Be *sure* that your exhaust is clean, by passing it through the

STRATTON JR. OIL SEPARATOR

More thorough in oil removal, because a spray of water is directed against the entering steam, to condense the vaporized oil. This oil collects in the form of oil-coated globules of water which are swirled out of the steam current by centrifugal force.

Clean, dry exhaust steam leaves the outlet.

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Moisture in compressed air results in decreased operating efficiency of pneumatic tools, hoists, pilot valves on air actuated equipment and other purposes.

Dry air will increase production the year round and will eliminate danger of freezing during the winter months.

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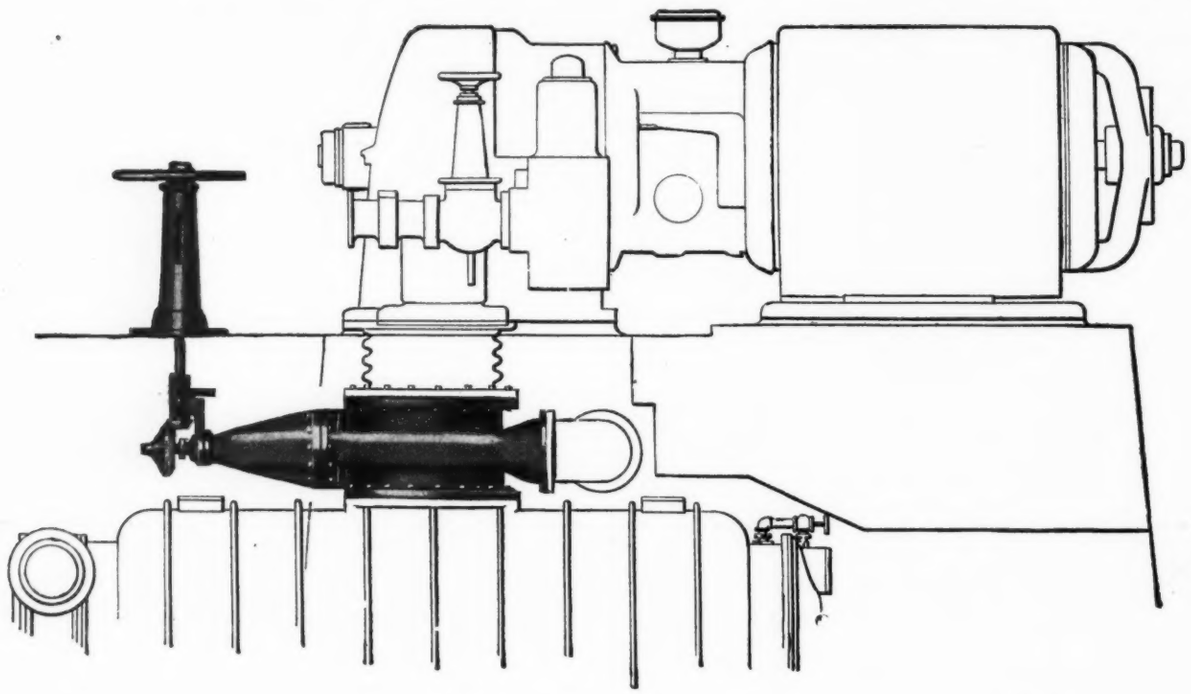
Turbine Exhaust Valve



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Saves space for the Condenser

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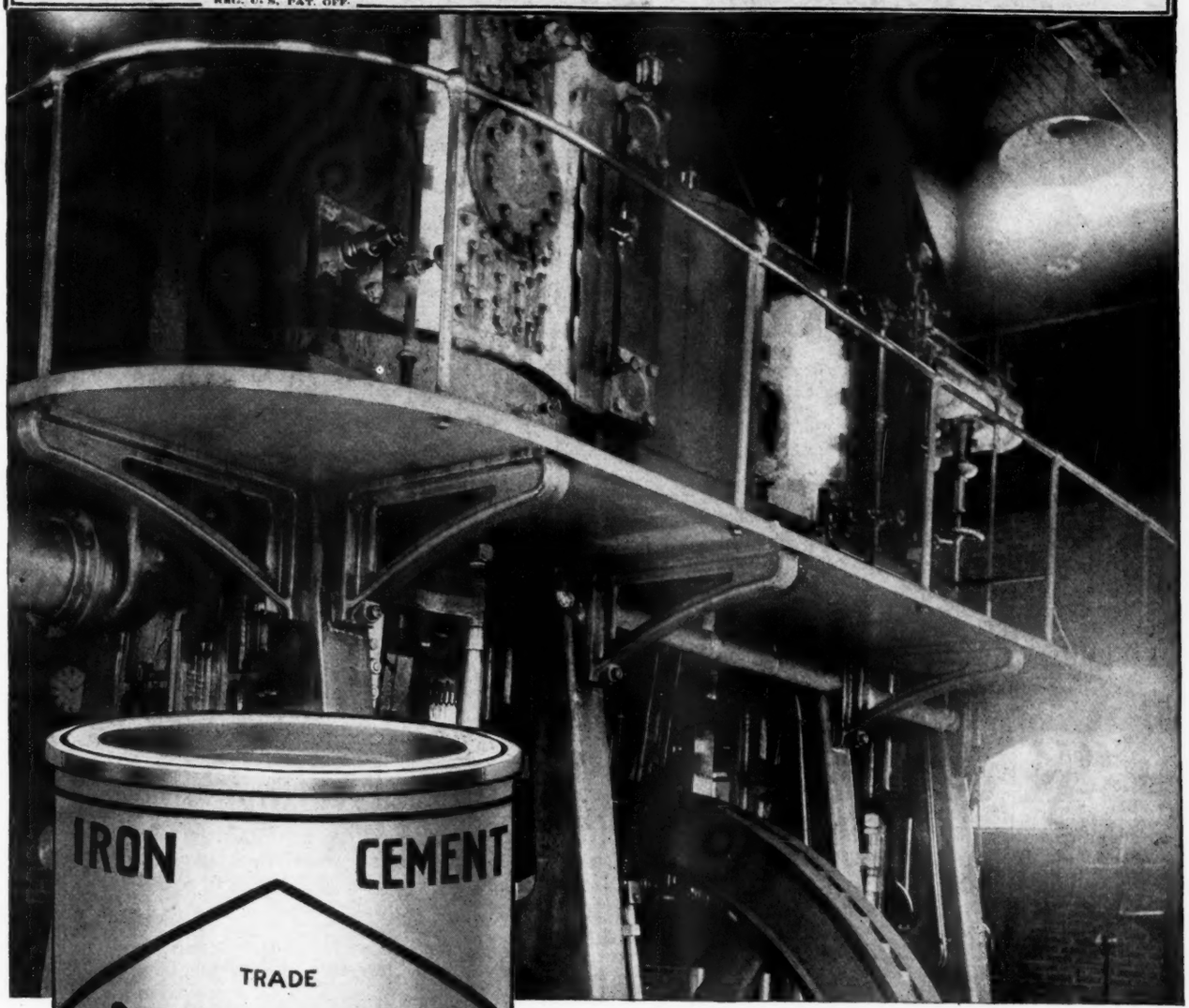

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Southwestern Distributor: R. V. Aycock Company, Kansas City, St. Louis, Tulsa, Houston

Va., Newmarket—E. T. Brown plans power development on Pit Springs River to develop 125 hp. Engineer not announced.

Va., Radford—The town, W. E. Gilbert, Mayor, is having plans prepared for power and light plant, $115,000. Engineer not announced.

W. Va., West Union—The West Union Machine & Supply Co., W. L. Lynn Secy. and Mgr., is in the market for 100 kw.a.c. generator.

Wis., Eau Claire—The Chippewa Valley Produce Co. is in the market for refrigerating and cooling apparatus.

Wis. Madison—The city, H. C. Buser, Clk., will receive bids until June 30 for air compressor for pumping station. Estimated cost $25,000. E. E. Parker, City Hall, Engr.

Wis., Sheboygan—E. A. Juul, Archt., 805 North 8th St., is receiving bids for 50 x 60 ft. power and engine house, including equipment, for the Phoenix Chair Co., 12th and Virginia Ave. Estimated cost $40,000.

Wis., Slinger—The Central Hotel Co., E. C. Kohl, Prop., is receiving bids for a steam heating plant and 2 boilers.

N. S., North Sydney—Cape Breton Cold Storage Co. plans to build a cold storage plant and is in the market for machinery and equipment for same. Estimated cost $200,000. Private plans. Address J. Clarke, c/o the company.

Ont., Chinnawa—The Ontario Hydro Comn., Sir Adam Beck, Chn., London, wants prices on 5 new transformers. The transformer station here was damaged by fire, loss about $200,000.

Ont., Kincardine—The Bd. Water Comn., H. Hudson, Chn., will soon award the contract for slow sand filters and equipment, motors, pumps, etc. Estimated cost $50,000.

Ont., Niagara Falls—The Niagara Falls Arena Co., Ltd., c/o G. Morse, Main St., plans to build ice arena and artificial ice plant. Estimated cost $50,000. Private plans.

Ont., Peterboro—The Utilities Comn., R. L. Dobbin, Waterworks Superv., is in the market for 5,300 Imp. gal. per minute pump, also 150 hp. induction motor with automatic compensator.

Ont., Thessalon—The town, J. O. Coulter, Clk., plans to install in the waterworks pumphouse, a motor driven pump and a gasoline driven pump, both centrifugal, 3 stage.

Ont. Toronto—The Bell Telephone Co., 76 Adelaide St. W., is having plans prepared for telephone exchange on Main St. Estimated cost $1,000,000. W. J. Carmechael, 118 North Dominion St. W., Montreal, Que., Archt.

CONTRACTS AWARDED

Cal., Los Angeles—H. H. Christie, Hollywood, has awarded the contract for 8 story, 40 x 137 ft. hotel on Hollywood Blvd., to Lange & Bergstrom, Washington Bldg., about $500,000.

Cal., San Luis Obispo—The Carpenter Hotel Co. has awarded the contract for 5 story, 86 x 160 ft. hotel, including steam heating system to the Rosene-Hunt-Sprager Co., 425 Pacific Finance Bldg., Los Angeles, $200,000.

Conn., Stamford—The Stamford Water Co., 271 Main St., has awarded the contract for construction of 2,000,000,000 gal. capacity reservoir and dam across Mill River to the Henry Steers Corp., 17 Battery Pl., New York. Estimated cost $750,000.

Ia., Chariton—The School Bd., P. T. Perry, Secy., has awarded the contract for 3 story, 110 x 154 ft. high school to C. W. Ennis, Grinnell, $160,000; steam heating, ventilating and plumbing, to E. W. Ensley, $32,000.

La., New Orleans—The U. S. Engineer's Office Room, 329 Custom House, has awarded the contract for turbo generator, etc., for dredge "Gulfport" to Westinghouse Electric & Mfg. Co., Union Bldg., Pittsburg, Pa., $24,861; condenser, etc., to A. M. Lockett & Co., Ltd., 521 Barrone St., $4,214. Noted May 2.

Mich., Sault Ste. Marie—The Cadillac Lumber & Chemical Co., Cadillac, has awarded the contract for structural steel for 1 story, 93 x 275 and 110 x 116 ft. saw mill to the Indiana Bridge Co., Muncie, Ind. Estimated cost $250,000. Noted May 2.

Minn., Glen Lake (Hopkins P. O.)—The Hennepin Company Sanatorium Comrs., E. S. Mariatte, Secy., Hopkins, has awarded the contract for 3 story, 90 x 180 ft. and 6 story 40 x 180 ft. buildings, also alterations to service building, to Pike & Cook, 416 South 5th St., Minneapolis, about $400,000.

Minn., Minneapolis—The State Bd. Control, D. F. Mullen, Secy., State House, St. Paul, has awarded the general contract for 6 story, 400 x 400 ft. library on the Campus to C. Skooglum, 502 Ryan Bldg., St. Paul, $926,856. Noted May 23.

Minn., St. Paul—The city has awarded the contract for 3 pumping units, including accessories and appurtenances, at McCarron's station, to Allis Chalmers Mfg. Co., 707 Metropolitan Life Bldg., Minneapolis, $140,700.

Minn., Sauk Center—The city, V. Conklin, Secy. Water, Light and Power Comn., has awarded the contract for waterworks improvements, distribution system to L. Goldstein, c/o L. P. Wolff, Engr., 1000 Guardian Life Bldg., St. Paul, $38,302; reservoir, A. Nelson, $10,748; well, J. F. Coyle, $4,400; pump house, D. A. Pangburn, $7,000. Contract for pumps, etc., will be awarded later. Noted May 30.

N. Y., Brooklyn—The Bd. Educ., 500 Park Ave., New York, has awarded the contract for 5 story P. S. No. 188 on Neptune Ave. and 33d St., to P. J. Brennan & Son, 624 Madison Ave., New York, $568,824. Noted June 13.

N. Y., Long Island City—The Wheeling Corrugating Co., 16 Desbrosses St., New York, has awarded the contract for 6 story factory on Nelson Ave., here, to the Foundation Co., 120 Liberty Ct., New York. Estimated cost $250,000.

N. Y., New York—The Boston Holding Co., c/o A. C. Bossom, Archt. and Engr., 680 5th Ave., will build 9 story apartment building, on East 49th St., by day labor. Steam heating system to be installed.

N. Y., New York—The 878 West End Corp., c/o R. Candela, Archt. and Engr., 200 West 72nd St., will build a 15 story apartment at 874 West End Ave. Work to be done by separate contracts under supervision of the architect.

N. Y., New York—J. G. Siegel, Inc., c/o Sugarman & Hess, Archts. and Engrs., 16 East 43rd St., will build 15 story, 100 x 120 ft. apartment hotel on West 81st St. by day labor.

N. C., Goldsboro—The State Hospital for Negroes has awarded the contract for power plant piping and apparatus, also water pumping equipment, heating and ventilating equipment, to B. McKenzie, Greensboro, $134,000.

N. C., Greensboro—The City Council has awarded the contract for the construction of 1,300 ft. dam across Reedy Fork Creek, near here, to create a 6,000,000,000 gal. reservoir, also installation of pumping machinery to W. W. Boxley Co., Roanoke, Va., $83,346, furnishing pumping machinery to I. Hardman, Charlotte, $8,496. Noted June 6.

N. C., Raleigh—The State Hospital has awarded the contract for additional refrigeration equipment to the Baltimore Constr. & Supply Co., 610 North Calvert St., Baltimore, Md., $25,645. Noted Feb. 21.

N. D., Hillsboro—N. G. Nyhus, Aud., has awarded the contract for electric distribution and lighting system to M. Hyland, 1114 Eighth Ave. N., Fargo, $31,000. Noted May 30.

Pa., Chambersburg—The borough has awarded the contract for 1 story, 80 x 90 ft., power house, to H. E. Shields. Noted March 1, 1921.

Pa., Greenville—The Greeneville Steel Car Co. will build 73 x 390 ft. factory and foundry by day labor. Estimated cost $200,000.

Pa., Phila.—The city has awarded the contract for coal and ash handling equipment to the Specialty Eng. Co., Trenton and Allegheny Aves., $65,208. Noted May 23.

Pa., Phila.—Girard College has awarded the contract for 2 story, 145 x 308 ft. armory and recreation building, including steam heating system, on Girard Ave. and Corinthian St., to I. E. Leighton, 126 North 12th St., $500,000. Noted June 13.

Pa., Phila.—Heyman Bros., Widener Bldg., has awarded the contract for 12 story, 82 x 145 ft. office bldg. to Wark Co., 231 South Broad St., $500,000. Noted Apr. 11.

Pa., Phila.—The Philadelphia Electric Co., 1000 Chestnut St., has awarded the contract for 2 story, 66 x 114 ft. substation, on 6th and Federal Sts., to I. E. Leighton, 126 North 12th St., $60,000.

Pa., Pittsburg—The Atlantic & Pacific Tea Co., Bay St., Jersey City, N. J., has awarded the contract for warehouse, garage and stable here, to the Turner Constr. Co., 11 Goodell St., Buffalo, N. Y. Estimated cost $500,000.

R. I., Providence—The Wanskuck Co., 1117 Douglas Ave., has awarded the contract for boiler house, also alterations to mill building, at Seneca Mills, to Willmarth-MacKillop, Inc., Freeman St., Pawtucket. Estimated cost $50,000.

Va., Norfolk—The city has awarded the contract for installing power, lighting and signal system for grain elevator under construction at Sewalls Point to the Electro-Mechanical Co., 432 North Calvert St., Baltimore, Md., $60,000.

W. Va., Huntington—The Consolidated Light, Heat & Power Co., Miller-Ritter Bldg., will build 2 story, 28x64 ft. substation on 2nd Ave. and 18th St., to supply street and commercial lighting to East End of city. Work will be done by day labor. Estimated cost $90,000.

Ont., Preston—The Preston Sanatorium Co., L. G. Hagmeier, Pres., has awarded the contract for 2 story, 40 x 370 ft. sanatorium to C. Braun, 295 King St. W., Kitchener. Estimated cost $225,000. Prices wanted on steam boilers and radiation. Noted June 13.

Ont., Windsor—The Windsor Hydro Electric System, 113 Chatham St., has awarded the contract for 36 x 84 ft. electric distribution station to Muxlow & Gale, Onellette Ave. and Erie St. $33,000.

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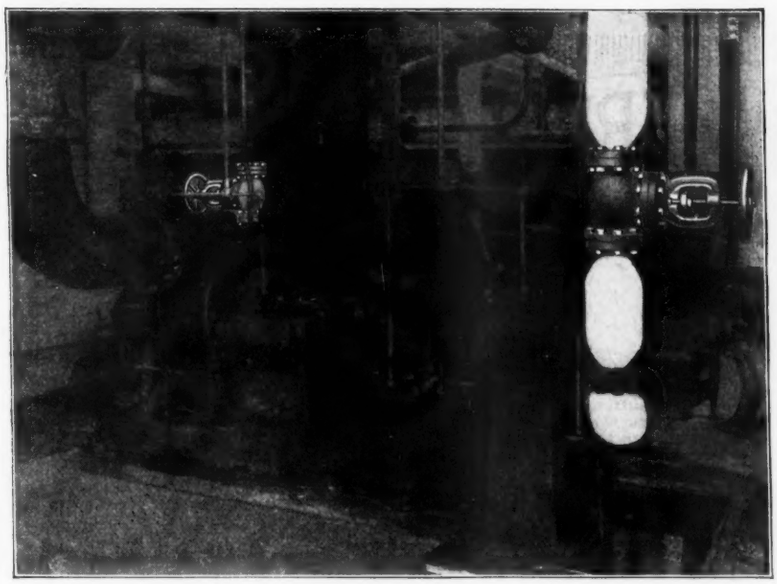

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New York

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OPERATING engineer wanted by an industrial concern in Jersey City, N. J., having two steam boilers, steam-driven electric generator, numerous electric motors and electric-driven refrigerating plant. Applicant should have experience in the operation of the above as well as thoroughly understanding economies in steam for steam is used in the process of manufacture. Position is permanent. State age, experience and references. P-28, Power.

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ENGINEER wanted for power plant consisting of two boilers and two engines, about four hundred horsepower each, driving electric generators and operating an electric railway. Address Mauch Chunk & Lehighton Transit Company, Mauch Chunk, Penna., stating age, experience, and monthly wages desired. Also giving references.

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Maintaining New York City office and calling on the jobbers of plumbing supplies in Metropolitan District and territory east of Pittsburgh—now representing old established manufacturer of plumbers' brass goods—desires one other account only of a reliable concern wanting New York office and representation in above mentioned territory on commission basis—twelve years' experience—best of references—must be a standard commercial product. RA-26, Power.

PATENT ATTORNEY

C. L. Parker, patent attorney, formerly member Examining Corps. U. S. Patent Office, McGill Bldg., Washington, D. C. Inventors' handbook sent upon request.

U. S. GOVERNMENT

Proposals for 4 Diesel Electric Seagoing Hopper Dredges. Office, Chief of Engineers, Room 2802, Munitions Bldg., Washington, D. C.—SEALED PROPOSALS will be received here until 12 o'clock noon, August 2, 1922, and then opened, for the construction of 4 Diesel Electric Seagoing Hopper Dredges. Further information on application.

SALES ENGINEER

familiar with boiler room practice to represent a long established company of highest standing in the sale of the most efficient coal-burning device on the market. None but those able to furnish the best of references will be considered. Commission basis only.

AS-980, Power,
935 Real Estate Trust Bldg., Phila.

For Sale—Cheap
Immediate Delivery

GENERATOR

1—40-kw. General Electric, 1050 r.p.m., form H, 125-v., D.C., with switchboard.

G. H. & J. T. KELLY, Elmira, N. Y.

1500 STEEL TANKS

Sizes from 2 ft. x 4 ft. to 25 ft. x 15 ft. Capacity from 100 gallons to 69,000 gallons. Stock included pressure tanks, mixing tanks, storage tanks, heating tanks and pump tanks.

Write for special Bulletin No. 7.

NASHVILLE INDUSTRIAL CORPORATION
Jacksonville, Tennessee

ENGINES

12-in. x 30-in. L. H. **Hamilton-Corliss.**

14-in. and 26-in. x 36-in. C. & G. **Copper Heavy Duty Corliss Engine** with or without **Condensing Outfit.**

PUMPS

30—New 10-in. x 6-in. x 12-in. **Buffalo Duplex B. F. Pumps.**

HOWARD W. READ

N. W. Cor. 3rd & Arch Sts., Phila., Pa.

AIR COMPRESSOR
INGERSOLL-RAND
11½ in. x 6 in. x 12 in. Type XB-2

This compressor, designed for 250 lb. working pressure, is absolutely new, it never having been set up, and is available for immediate shipment from St. Paul stock, subject to prior sale at a

REDUCED PRICE

For Complete specifications and price write
Robinson, Cary & Sands Company
St. Paul, Minnesota.

Ames Uniflow Engine

Horizontal heavy duty, side crank, Poppet-valve, Una-flow controlled compression type; arranged with shaft, outer bearing and supports suitable for direct connection to 450-kva. size alternator. Cylinder 24 in. diameter, 30-in. stroke. Steam pressure at throttle 160 lbs., r.p.m. 150. Parties contemplating power installations of any kind within the capacity of the engine, will do well to look into this proposition. Any further information desired will be given on request. Engine brand new, never used. Address,

Benjamin Electric Mfg. Co.
120 So. Sangamon St., Chicago, Ill.

One Wheeler Surface Condenser

2100 sq. ft.
Admiralty Type
Great Bargain for quick sale.

H. E. Salzberg Co., Inc.,
30 Church St., N. Y. City

AIR COMPRESSOR

Steam Driven

BARGAIN

Ingersoll Class FR-1, straight line air compressor, size 10 x 10 x 10, capacity 250 ft. per minute, automatic cut-off piston valve, fly wheel governor, complete with unloading valve and air operated throttle; machine run less than one year; can be seen operating.

BROWN & BIGELOW, INC.
St. Paul, Minn.

Power Machinery Exchange

1 Montgomery Street, Jersey City, N.J.

A. C. Direct-Connected Units—3- or 2-Phase

Kva	Generator	Engine
640	Wghse.	Hamilton Co. liss
625	Wghse.	Parsons Horiz. Turbine
600	Gen. Elec.	Rice-Sargent-Corliss
500	Allis-Chal.	Allis-Chal.-Corliss
500	Allis-Chal.	Allis-Chal. Turbine
400	Wghse.	Erie Ball, 4-valve
400	Wghse.	Hamilton Corliss
375	Gen. Elec.	Erie Ball, 4-valve
375	Gen. Elec.	Curtis Horiz. Turbine
360	Gen. Elec.	Harris Corliss
350	Wghse.	Murray Corliss
300	Gen. Elec.	Allis-Chal.-Corliss
250	C-W	Harrisburg, 4-valve
250	Wghse.	Erie City, 4-valve
250	Wghse.	Murray Corliss
200	Wghse.	Erie Ball
200	Wghse.	Harrisburg, 4-valve
187	Gen. Elec.	Skinner compound
180	Gen. Elec.	Chandler Taylor, side crank
150	Gen. Elec.	Ames Uniflow
125	Gen. Elec.	Curtis Horiz. Turbine
125	Wghse.	Harrisburg, 4-valve
100	Wghse.	Erie Ball
100	Ridgway	Ridgway, side crank
90	Allis-Chal.	Skinner
75	Gen. Elec.	Harrisburg
75	Ridgway	Ridgway, side crank
70	Wghse.	Skinner
50	West. Elec.	Erie Ball
40	Fbks.-Morse	Lycoming

A. C. Belted Generators, Units—3- or 2-Phase

Kva.	Make	Speed
800	Allis-Chalmers, 3 Brg.	360
500	Allis-Chalmers	600
400	General Electric, 3 Brg.	600
360	Westinghouse	360
312	General Electric	450
280	Allis-Chalmers	450
250	Allis-Chalmers	600
200	General Electric	600
200	Westinghouse	600

Kva.	Make	Speed
170	General Electric	400
150	General Electric	600
100	General Electric	900
75	Westinghouse	900
60	Electric Machinery	600
50	General Electric	1200
40	Electric Machinery	1200
37½	General Electric	1200
30	General Electric	1200
15	Fairbanks-Morse	1200

A. C. Motors 3- and 2-Phase

Hp.	Make	Volts	Speed
300	Gen. Elec., Synch.	2300	720
200 (3)	Gen. Elec., slip ring	2300-440-220	585
150	Gen. Elec., slip ring	440	720
100	Wghse., slip ring	2300	580
100	Allis-Chal.	440-220	680
85	Gen. Elec.	2300-550-220	720
50	Wghse.	440-220	850
40	Wghse.	440-220	850
30	Wghse.	440-220	850

Also smaller sizes

Direct-Current Units 220-250-Volt.

Kw.	Generator	Engine
17½	Wghse.	Erie
20	Gen. Elec.	Gen. Elec.
25	Gen. Elec., 3 wire	Troy Vertical
35	Ridgway	Ridgway
35	Allis-Chal.	Skinner
50	Wghse., 3-wire	Ames
50	Gen. Elec.	Erie Ball
75	Sturtevant	Sturtevant
75	Burke, 3-wire	Ames
75	Allis-Chal.	Erie Ball
85	Cr.-Wh.	Erie Ball
100	Cr.-Wh.	Harrisburg, side crank
100	Allis-Chal.	Skinner
125	Gen. Elec.	Ball Tandem
125	Wghse.	Erie, side crank
150	Wghse.	Hewes Phillips Corliss
150	Ridgway	Ridgway
150	Gen. Elec.	Erie, 4-valve
200	Gen. Elec.	Bates Corliss
200	Ridgway	Ridgway
250	Cr.-Wh.	Harrisburg
250	Gen. Elec.	Erie Lentz
250	Triumph, 3 wire	Skinner tandem
300	Cr.-Wh.	Watts-Campbell-Corliss
300	Wghse.	Lane & Bodley Corliss
400	Gen. Elec.	Buckeye comp.
800	Ridgway	Rdgway Turbine

Oil Engines

Hp.	Make	Type
300	De La Vergne	FH
180	Allis-Chal.	Semi-Diesel
100	Fairbanks-Morse	Y
85	Bessemer	Elec. Light
75	Fairbanks-Morse	Y
60	Muncie	C Heavy Duty
50	Fairbanks-Morse	Y
50	De La Vergne	HA
37½	Fairbanks-Morse	Y
30	Muncie	A
25	Fairbanks-Morse	Y
20	Fairbanks-Morse	Y
15	Meitz & Weiss	Hor.

Direct-Connected Oil and Gas Units

Kva	Generator	Engine
160	G. E., 2-60-2300-v.	Diesel Oil, 3-cyl.
100	G. E., 3-60-2300-v.	Diesel Oil, 4-cyl.
150	Allis-Chal., 250-v.	Diesel Oil, 3-cyl.
125	Allis-Chal., 230-v.	Turner Frick, gas, 4-cyl
75	Wghse., 230-115-v.	Diesel Oil, 3-cyl.

Feed Water Heaters

and Storage Heaters

6—Webster Class B, Feed Water Heaters. Capacity 11,000 b.hp. Size 10 ft. 5 in. x 9 ft. 10 in. x 8 ft. 7 in.

8—Patterson-Allen closed Water Heaters. Capacity 30,000,000 B.t.u. or 470 gallons per minute. Size 44 in. x 10 ft. 2 in.

6—Patterson-Allen closed Water Heaters. Capacity 8,000,000 B.t.u. or 126 gallons per minute. Size 24 in. x 8 ft. 6 in.

1—Patterson-Kelly vertical closed Water Heater. Capacity 350 hp.

24—Whitlock Instantaneous and Storage Heaters, various sizes.

Priced extremely low for quick sale. Write for particulars.

Nashville Industrial Corporation
Jacksonville, Tennessee

IMMEDIATE DELIVERY!

BRAND NEW HEWES & PHILLIPS CORLISS STEAM ENGINES

with manufacturer's guarantee at

extremely low prices

4—14 x 30—135 hp., designed for belt drive.

1—16 x 24 Heavy Duty Franklin type arranged for direct connection to electrical generator. Power rating, 275 hp. at 150 pounds and 150 r.p.m., 300 hp. at 150 pounds and 164 r.p.m.

ESSEX ENGINE & MACHINE CORPORATION
Newark, N. J.
Successors to
HEWES & PHILLIPS IRON WORKS

Oil and Gas Engines For Sale

Prompt Deliveries

NEW AND REBUILT FULL DIESEL TYPE OIL ENGINES

2—450 b.hp. vert. 6 cyl. coupled to 3 ph., 60 cyc., A.C. generators.
1—450 b.hp. vert. 6 cyl. belted.
2—225 b.hp. vert. 3 cyl. bltd. of cpld.
1—225 b.hp. vert. 3 cyl. coupled to 200 kva., 3 ph., 60 cyc., 1200 volt genr.
1—170 b.hp. vert. 3 cyl. belted.
1—120 b.hp. vert. 3 cyl. coupled to 85 kw., 3 ph., 60 cyc., 2300 volt genr.
1—120 b.hp. vert. 3 cyl. coupled or bltd.

SEMI-DIESEL OIL ENGINES

1—60 b.hp. vert. sgl. cyl. 2 cyc. bltd.
1—40 b.hp. vert. sgl. cyl. 2 cyc. bltd.
2—25 b.hp. horiz. F. M. type "Y" bltd.

GAS ENGINES

1—150 b.hp. vert. 3 cyl. coupled to 100 kw., 250 v. D.C. Genr.
1—100 b.hp. vert. 3 cyl. coupled to 62½ kw., 125-250 v. D.C. Genr.

Above only partial list—write or wire us full details your requirements.

A. McMILLAN
Specialist in Diesel Oil and Internal Combustion Engineering.
628 Monadnock Block, Chicago

REBUILT STRAIGHT LINE ENGINES

1—11 x 16, 60 hp., 220 rev.
1—15 x 15, 170 hp., 240 rev.
2—17 x 15, 200 hp., 240 rev.

The Straight Line Engine Co., Inc.
Syracuse, N. Y.
WRITE US

TRIPLEX PUMPS

(Brass Fitted)

3 x 4..... 21 G.P.M.
4 x 6..... 45 G.P.M.
4⅜ x 6 Ball Valve, 56 G.P.M.
5½ x 8.....108 G.P.M.
7 x 8.....180 G.P.M.
8 x 12.....260 G.P.M.

MARVIN BRIGGS, INC.,
167 Sixth St. Brooklyn, N. Y.

USED OIL ENGINES

20, 35, 40, 50, 60, 85, 100, 120, 140, 150, 200, 225, 280 and 500 H.P. used oil engines in good condition. Write for prices.

ROBERT P. KEHOE
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Telephone Vanderbilt 9595

CORLISS ENGINES

20—18 x 36 Corliss Engines, 350 HP., heavy duty mill type, either right hand or left hand. Fly wheel 11 ft. x 32 in. Can furnish either new or used. Complete specifications and photographs on request.

Priced extremely low for quick sale.

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Jacksonville, Tennessee

MAC GOVERN & COMPANY INC. POWER MACHINERY

114 Liberty Street — New York, N. Y.

ENGINE-GENERATOR UNITS—FOR PROMPT SHIPMENT

ALTERNATING CURRENT—60 CYCLE

1—500 kw., Allis-Chalmers, 2300 v., 120/150 r.p.m., dir. conn. to 26 in x 36 in. Allis-Chalmers horiz., 4-valve engine.
1—500 kw., Westg., 2300 v., 120 r.p.m., dir. con. to 26 in. x 42 in. Hamilton Corliss engine.
1—450 kw., Gen. Elec., 2300 v., 100 r.p.m., dir. con. to 22 in. and 42 in. x 48 in. E. P. Allis cross compound engine.
1—325 kva., Allis-Chalmers, 2300 v., 120 r.p.m, dir. conn. to 16½ in. and 40 in. x 36 in. Buckeye horiz. tandem engine.
1—300 kva., Gen. Elec., 2300 v., 150 r.p.m., dir. con. to 23 in. x 30 in. Erie City, 4-valve engine.
1—300 kw., Gen. Elec., 2400 v., 150 r.p.m., dir. conn. to 24 in.-30 in., Ball Corliss valve engine.
1—250 kw, Allis-Chalmers-Bullock, 240 v., 150 r.p.m., dir. con. to Erie Ball, 4-valve, totally enclosed type engine.
1—200 kw., Westg., 2200 v., 180 r.p.m., dir. con. to 18 in. and 30 in. x 24 in., Harrisburg, 4-valve cross compound engine.
1—175 kva., Gen. Elec., 220/440 v., 257 r.p.m., dir. con. to 16 in. x 16 in., Chandler & Taylor, slide valve engine.

DIRECT CURRENT—250 VOLTS

1—500 kw., Ft. Wayne, 10 pole, 90 r.p.m., dir. con. to 22 in. and 38 in. x 48 in., Bates cross compound engine.
1—425 kw., Gen. Elec., 8 pole, 80 r.p.m., dir. con. to 24 in. x 48 in., Hamilton Corliss right hand, heavy duty engine.
1—375 kw., Allis-Chalmers, 220/230 v., 10 pole, 120 r.p.m., dir. con. to 15 in. and 30 in. x 36 in., Putnam horiz., cross compound engine.
1—250 kw., Gen. Elec., 250/275 v., 200 r.p.m., dir. con. to 26 in. x 18 in., Ball & Wood right hand engine.
1—200 kw., Westg., 200 r.p.m., dir. con. to 21 in. x 24 in., Porter Allen side crank engine.
1—175 kw., Gen. Elec., 220/250 v., 110 r.p.m., dir. con. to 18¾ in. x 33 in., Buckeye engine.

125 VOLTS

1—150 kw., Crocker-Wheeler, 25 r.p.m., dir. con. to 18 in. x 17 in., Harrisburg Fleming, right hand, side crank engine.

125-250 VOLTS—3-WIRE

2—150 kw., Westg., 8 pole, 250 r.p.m., dir. con. to 17 in. x 16 in., Harrisburg, horiz. left hand, side crank engine
2—75 kw., Western Elec., 6 pole, 275 r.p.m., dir. con. to 14 in. x 14 in., Chandler & Taylor engines.
1—50 kw., Westg., 8 pole, 250 r.p.m., dir. con. to 12 in. x 12 in., Harrisburg, horiz., piston valve engine.

This is only a partial list. Complete list will be mailed upon request. We are in the market to buy. Advise us what you have to dispose of.

GENERATOR SETS

1—150-kw., 230-v., D.C., General Electric Generator, dir. conn. to Ames simple horiz. Automatic Engine.
1—100-kw., 230-v., D.C., General Electric Generator, dir. conn. to Ames simple horiz. Automatic Engine.
1—100-kw., 230-v., D.C. American-Ball Generator, dir. conn. to American-Ball simple horiz. Automatic Engine.

BOILERS

1—200-hp., 78-in. x 20-ft. Erie City horizontal return tubular. A.S.M.E. code, 125-lb. pressure.
3—150-hp., 72-in. x 18-ft. Frost horizontal return tubular. A.S.M.E. code, 150-lb. pressure.
2—150-hp., 72-in. x 18-ft. Frost horizontal return tubular. A.S.M.E. code, 125-lb. pressure.

THE ABOVE BOILERS ARE PRACTICALLY NEW. INSURABLE AT PRESSURES NAMED IN ANY STATE.

LARGE STOCK VERTICAL, LOCOMOTIVE and WATER TUBE BOILERS, AIR COMPRESSORS, ENGINES, PUMPS and MACHINE TOOLS.

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Steam Turbos, 60 cy., 3 Ph., Etc.

NEW 12,500-kva., 33,000-11,500-v. TURBO.
5000-kw., 2300-v. Turbo, 80% P.F.
625-937-kva., 2300-v. Cond.
1560 & 1250 kva., Non-Cond. 600-6600 v.
250 & 625 kva., Non-Cond. 240-480 v.
625-125-187 kva., 2300-v. Non-Cond.
780-kva., 480-v., MIXED PRESS. TURBO.
800- & 1000-kw., D.C., 250-125-v. Turbo.
1560-1250-625-kva. FREQ. CHANGERS.
NEW 750-kw. M. G. SET, 60 cy., 125-250 v.
600-400-150-kw. Engine Sets, 275 v.
NEW 468-hp., 187 rev., 25-cy., 2200-v. Motor.
937-kva., 2300-v., 3-ph., 60-cy., Comp. Eng. Motor.
1—823-hp., 200-lb. Boiler Edgemoor, $10 hp.
4—512-hp. Boilers, B. & W., 200 lb., with Stokers.
20—Boiler Feed Pumps, Turbo & Motor Drive.
4—NEW 290-hp. B. & W. BOILERS, 200 lb.
AIR COMPRESSORS, ROCK CRUSHERS, CONTRACTORS' EQUIPMENT, ETC.
Send us your inquiries.

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Indianapolis, Ind.

New Stirling Boilers

Two 1000-b.hp. Stirling Boilers with superheaters and soot blowers, built for 275-pounds working pressure and having a heating surface of 10,144 square feet each.

The superheaters are the B & W type and are designed to raise the temperature of the steam approximately 150 degrees above normal steam pressure at capacity. Each boiler is equipped with twelve unit Diamond Soot Blowers.

These boilers are absolutely new and will be delivered directly from the Barberton shops of the Babcock & Wilcox Company. We must move these boilers quickly. Therefore,

We offer them at a considerable reduction in price.

Communicate with Mr. Oscar L. Bulkeley, General Superintendent of the Board of Water and Light Commissioners, Lansing, Mich.

Surety Bonded

Direct Current Engine Generator Sets, 125-250 Volts

1—30-kw., 125-v., 350 r.p.m., Bullock Generator, dir. con. to 1—Skinner automatic steam engine, complete with valves, piping, and switchboard.
1—37½-kw., 115/125-v., 1000 r.p.m., cp. wd. Allis-Chalmers, D.C. Generator, belted to 1—50-hp., 350 r.p.m., 100-lb. steam pressure, horizontal, single cylinder, center crank, Atlas steam engine, complete with all accessories, including switchboard.
1—75-kw., 250-v., 175 r.p.m., cp. wd. Allis-Chalmers, D.C. Generator, dir. con. to Chandler & Taylor horizontal, single cylinder, side crank, slide valve steam engine, 14 x 14, 100 lb. steam pressure, complete with all accessories, including switchboard.
1—150-kw., 250/125-v., D.C., 3-wire engine Generator Set, consisting of 2—75-kw., 125-v., D.C. Burke Generators, mounted on common shaft, and coupled to 2—Fleming-Harrisburg single cylinder, 2-valve, Steam Engine, to operate 125 lb. steam pressure, complete with all accessories, including switchboard.
1—250-kw., r.p.m., cp. wd., 250-v. Crocker-Wheeler, D.C. Generator, dir. con. to and mounted on common base with 1—Fleming-Harrisburg, horizontal, single cylinder, piston valve, center crank, steam engine, 22 x 22, complete with all accessories, including switchboard.

New and Renewed Motors Up to 200 hp. Selling Below Wholesale Prices.

Duquesne Elec. & Mfg. Co.
(Opp. East Liberty Sta.)
Pittsburgh, Pa.
Licensees: Surety Motor Bonding Co.

BOILER AND ENGINE

150 HP., 72 in. x 18 ft., Flush Front, Horizontal tubular boiler. Recent inspection permits 115 lb. steam pressure with injector, boiler feed pump and Blake & Knowles open feed water heater.
200 HP., Armington & Sims Automatic cut-off engine with 2 wheels for belted service. All at Elizabethport, New Jersey.

FS-2, POWER,
10th Ave. at 36th St., New York City

B. & W. WATER TUBE BOILERS

4—400 HP. and 2—450 HP.

Vertical headers, longitudinal drums—42 in. x 20 ft. 4 in., 160-lb. pressure, 3935 sq. ft. heating surface, 18-ft. x 4-in. tubes, each complete with Illinois chain grate stokers and regular fittings. Equipment in good operating condition and a bargain.

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Water Tube—H.R.T.—Marine

The Markman Engineering Company
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RETURN TUBULAR LOCOMOTIVE

BOILERS

WATER TUBE SCOTCH MARINE

Brand New and Partially Used

A LARGE STOCK OF HIGH-GRADE BOILERS OF PRACTICALLY ALL SIZES, TYPES AND MAKES, TAKEN OVER FROM DU PONT CHEMICAL COMPANY'S AND OTHER PLANTS WITH PRODUCTION RECORDS—RECONDITIONED, OFFERED SUBJECT TO ANY INSPECTION, AVAILABLE *NOW!*

"SAVE TIME AND MONEY ON YOUR POWER INSTALLATION—
LET DAVIS FURNISH THE BOILERS"

LONG DISTANCE TELEPHONE RANDOLPH 2232

J. F. DAVIS

1122-1123-1124 Harris Trust Building CHICAGO, ILL.

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Available Now ! !

AIR COMPRESSORS

1—Sullivan Straight Line Air Compressor, 24 in. steam cylinder, 26 in. low pressure air cylinder, 16½ in. high pressure air cylinder, 30 in. stroke, capacity 1850 cu. ft. per minute.
1—Laidlaw-Dunn-Gordon Belt Driven Air Compressor, size 25 in. x 15 in. x 18 in., capacity 1750 cu.ft.
1—Chicago Pneumatic Single Stage Steam Driven Compressor, two cylinders, size 22 in. x 16 in., capacity 1700 cu.ft.
2—Ingersoll-Rand Two Stage Belt Driven Air Compressors, size 10 in. x 12 in. x 16 in.; capacity 888 cu.ft.
1—Laidlaw-Dunn-Gordon Belt Driven Air Compressor, size 25 in x 15 in. x 18 in.; capacity 750 cu. ft.
1—Ingersoll-Sergeant High Pressure Steam Driven Air Compressor, two-stage, low pressure cylinder 18 in. x 12 in., high pressure cylinder 12 in. x 12 in.; capacity 600 cu. ft.
1—Clayton Duplex Steam Driven Air Compressor, duplex steam and two stage air cylinders, dial steam cylinder 10 in, low pressure air cylinder 16¼ in., high pressure air cylinder 10 in., stroke 10 in.; capacity 425 cu. ft.
1—Ingersoll-Sergeant Duplex Two Stage Belt Driven Air Compressor, size 16¼ in. x 10¼ in. x 10 in.; capacity 380 cu. ft.
1—Chicago Pneumatic Fuel Oil Driven Compressor; cap. 300 cu. ft., 100 lb. pressure.
12—New York Air Brake Co., Locomotive Type Two Stage Air Compressors, 10 in. low pressure cylinder, 8 in. high pressure cylinder, 88 in. stroke, 7 in. steam cylinders.

BOILERS

1—B. & W., 284 HP., Water Tube; 150 lb. pressure.
1—Erie City, 250 HP., Water Tube; 150 lb. pressure.
14—72 in. x 18 ft. Kewanee Horizontal Tubular; 125 lb. pressure.
2—66 in. x 20 ft., Horizontal Tubular; 115 lb. pressure.
1—72 in. x 16 ft., Horizontal Tubular; 115 lb. pressure.
1—100-hp., Loco. Fire Box; 900 lb. pressure.
1—50 HP., Locomotive Fire Box; 90 lb. pressure.
1—50 HP., Internally Fired; 90 lb. pressure.
1—30 HP., Vertical; 110 lb. pressure.
1—20 HP., Vertical; 100 lb. pressure.

Send for a free copy of Bulletin No. 205, describing our complete stocks of Machinery and Equipment.

HARRIS BROTHERS CO.
35th and Iron Sts., Chicago, Ill.

FOR SALE

Brand New Complete Power Plant

BOILER PLANT

2—New (never fired) 520 HP. Babcock & Wilcox water tube boilers, A. S. M. E. code, 200 lb. working pressure, 5201 sq. ft. heating surface, including also:—B & W superheaters, Type "S" Diamond Soot Blowers, Type "E" Combustion Engr. stokers, forced draft equipment turbine driven, vacuum ash conveyor system, 2500 HP. feed water heater.

2—Worthington 14 x 8½ x 15 Duplex boiler feed pumps, valves, steam lines in boiler room.

ELECTRIC GENERATING EQUIPMENT

1—New (never operated) 1000 KW Bleeder type turbo-generator set, Kerr turbine, Allis-Chalmers generator, 3-ph. 60-cycles, 480-v, 3600 Rpm; mounted on common base plate; also one 50 KW motor generator exciter; 2075 sq. ft. Wheeler surface condenser with air and centrifugal pumps; 19 panel switchboard (which can be split up if desired); 36-in. exhaust gate valve; 36-in. expansion coupling. Can be arranged for 550,600 or 2300 volts.

6—B & W 440 HP. Boilers, A. S. M. E. code; 200 lb. working pressure; fired six months.

2—B & W 440 HP. Boilers, A. S. M. E. code; 200 lb. working pressure; 5 years old.

(These 8 boilers have steel headers, independent settings, etc., and are equipped with Murphy Stokers and Diamond Soot Blowers.)

8—B & W 440 HP. Boilers, built for 200 lb. working pressure, 10 years old, equipped with Roney Stokers.

TECHNICAL PRODUCTS COMPANY, Inc.

300 Madison Avenue, New York City

Machinery Utilities Co.

501 Fifth Avenue New York

GENERATOR SETS

1—1000 kva., Westinghouse low pressure Turbine, 600-v. 60-cy., 3-ph.
1—350-kw. Ft. Wayne Generator, 2300-v., 60-cy., 3-ph., direct connected to tandem compound engine.
2—350-kw., 120-v., D.C., Allis-Chalmers Generators, direct connected to 2-cyl., 21 x 30 in. gas engine.
3—135-kw., Westinghouse Generators, 2400-v., 60-cy., 3-ph., direct connected to full Diesel Oil Engine.
2—75-kw., 125-v., D.C., Westinghouse Generators, direct connected to 14 x 14 steam engine.

UNDERWRITERS

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1500 Gallon, 20 x 12 x 16 Buffalo Duplex, six hose valves.
1000 Gallon, 18 x 10 x 12, Knowles Duplex, four hose valves.
500 Gallon, 14 x 7 x 12 Knowles Duplex, two hose valves.

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Jersey City, N. J.
Established 1900

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FOR SALE

Three self supporting steel stacks 20-ft. diameter at base tapering to 16-ft. diameter at top; height 250-ft. Two are new, other used three months.

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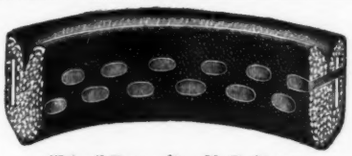

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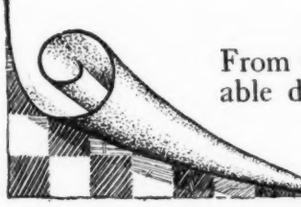

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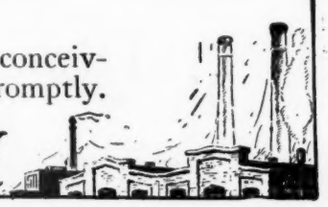

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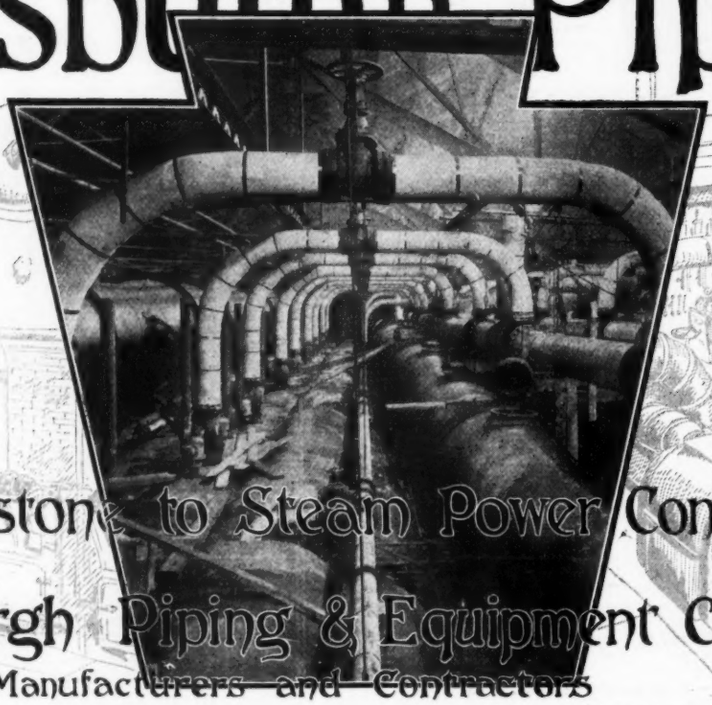

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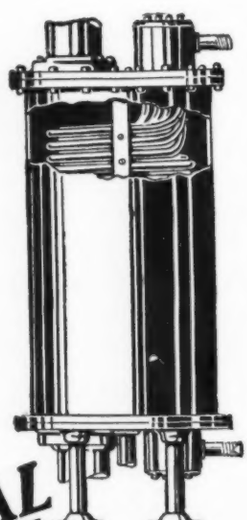

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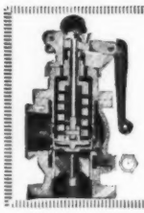

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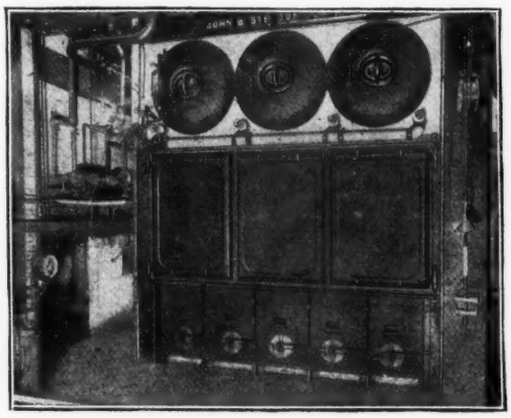

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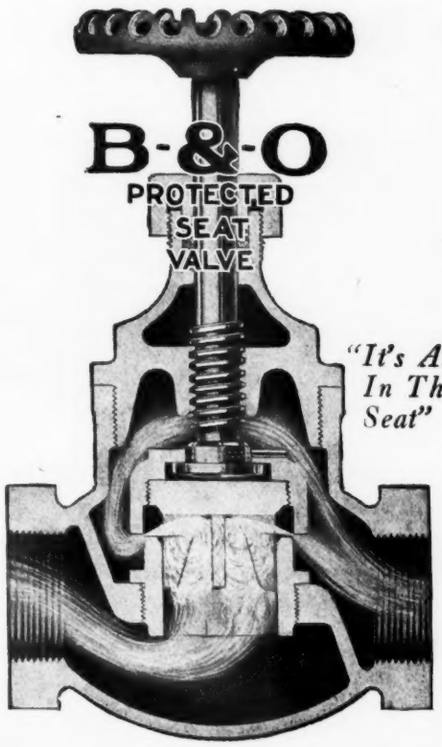

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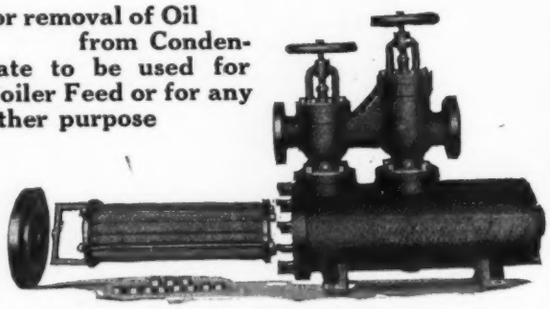

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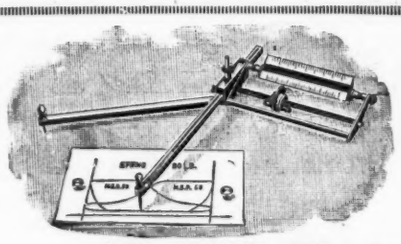

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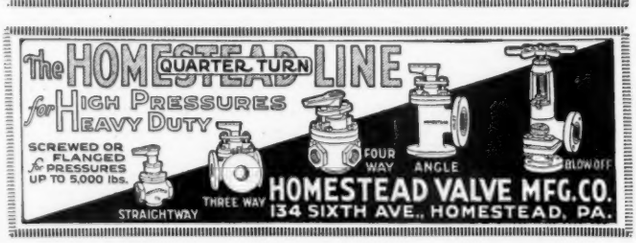

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THE FIREPROOF VENTILATING FLOORING

Where a safe floor to walk or work or wheel upon is wanted—indoors or out—**Irving Subway** is the one logical choice. Its narrow edge-on steel members grip the foot even when polished bright with use—and even with oil, grease, water or ice upon them. It makes a clean floor, a dry floor, a floor that helps toward higher plant efficiency because men working on it feel comfortable and secure.

Irving Subway is the most economical flooring you can use—because its moderate first cost is the one and only cost.

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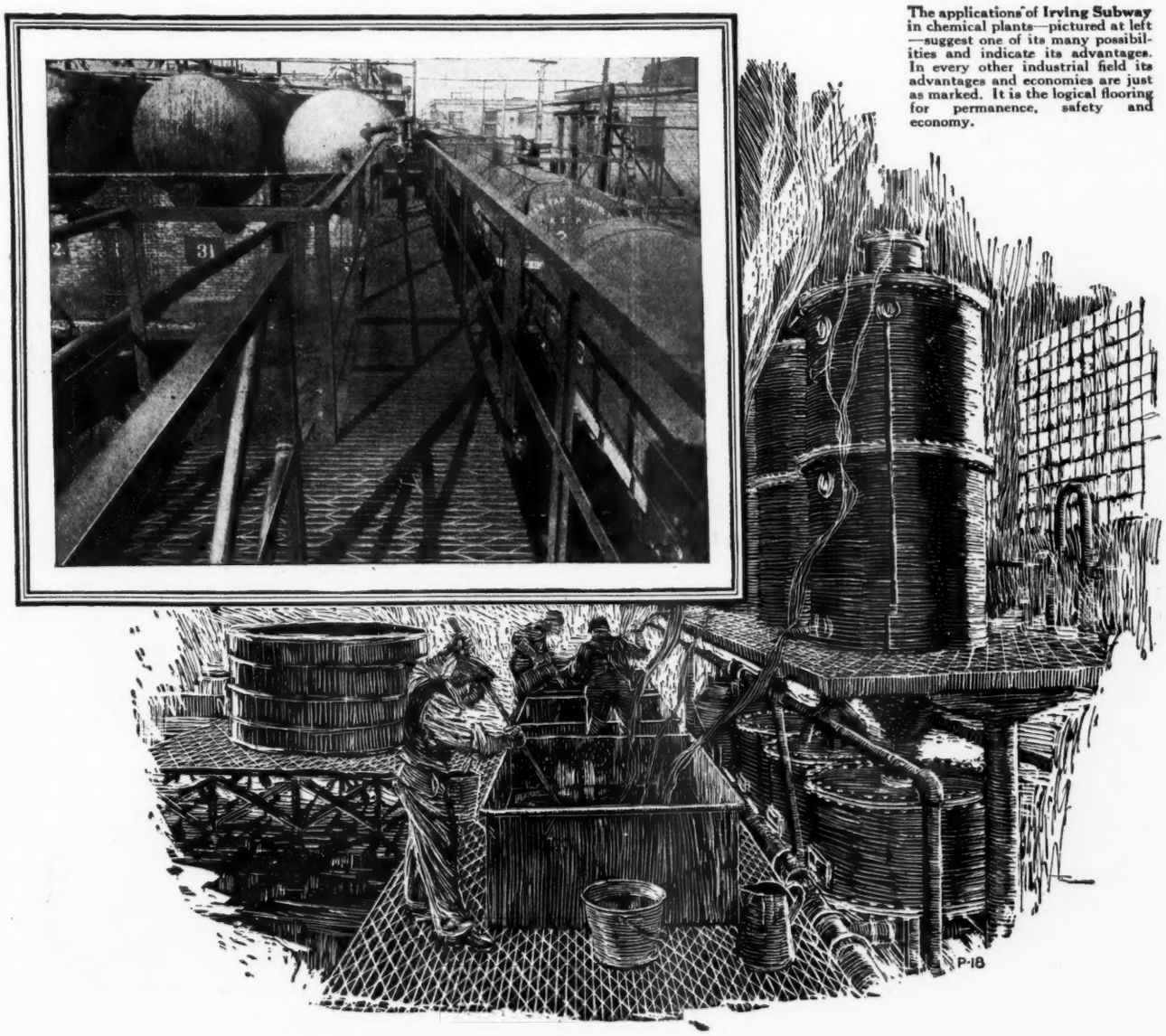

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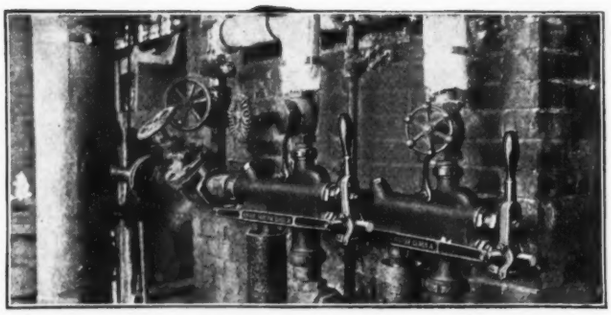

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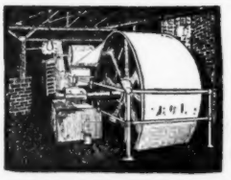

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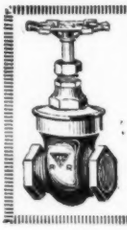

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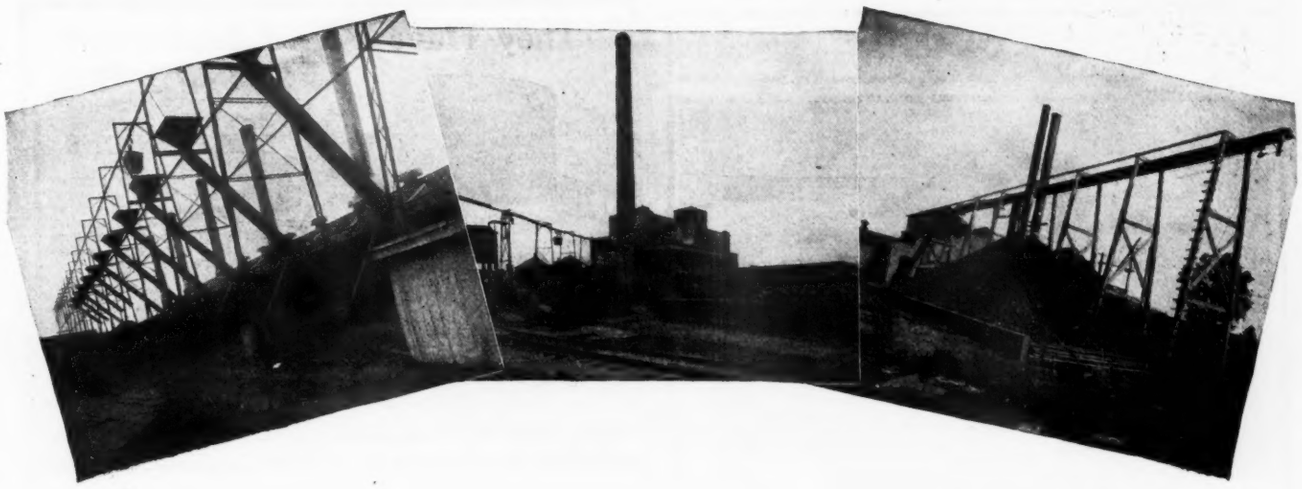

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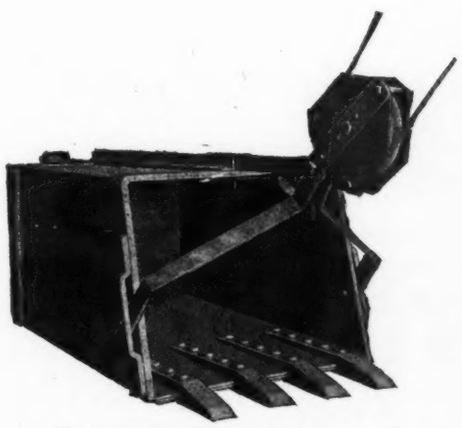

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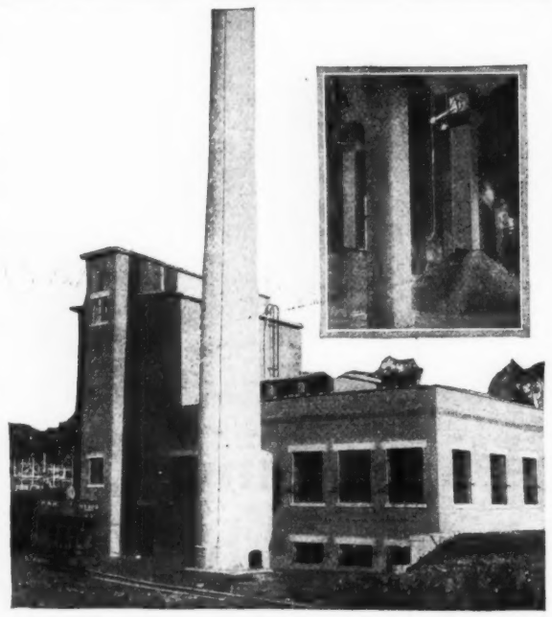

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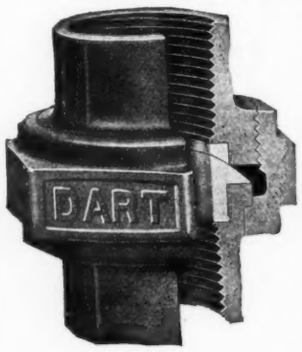

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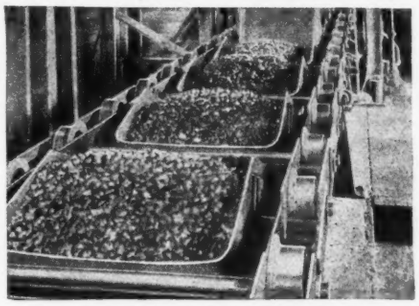

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Save coal and increase boiler capacity. Indispensable for economy. Let us put the engineering facts before you.

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Insures maximum safety and flexibility. Easily installed on existing valves. ***Write for Bulletin***

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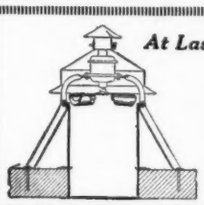

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The motor of this Four Leaf Clover vertical exhaust fan is entirely outside of the air or gas passage. *Write today for Bulletins 1 and 2*

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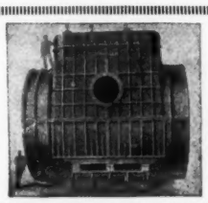

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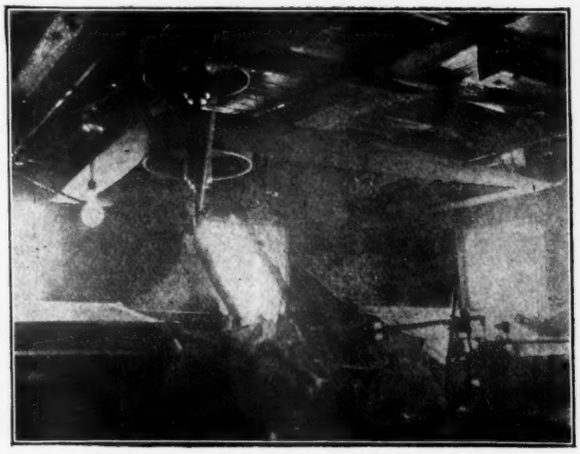

Not the Chance Record of a Single Belt

THIS mule drive with its quarter turns was a trouble maker. You can see the drops of condensed steam on the beams over the belt. On two occasions this excessive moisture caused the belt to shrink so much that it broke the shafting that carries the pulley on the extreme right—and these belts were supposed to be water-proof!

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The dependability and economy of "COMMANDER" in this mill has been proven, not by the chance record of a single belt, but by the steady performance of successive belts.

And, as if this were not sufficient recommendation, the superintendent told us that the outstanding feature of "COMMANDER" is its lack of stretch.

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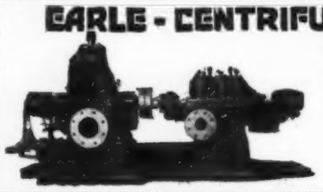

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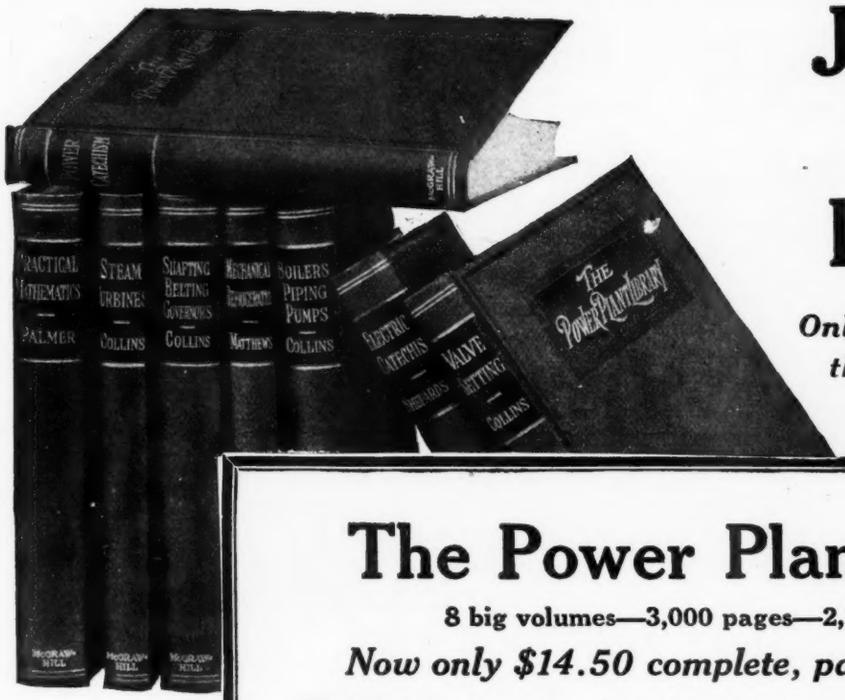

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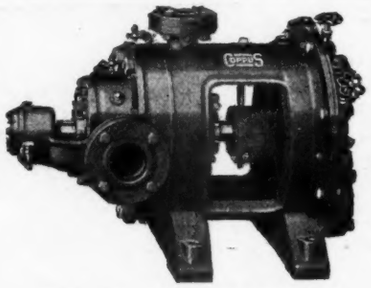

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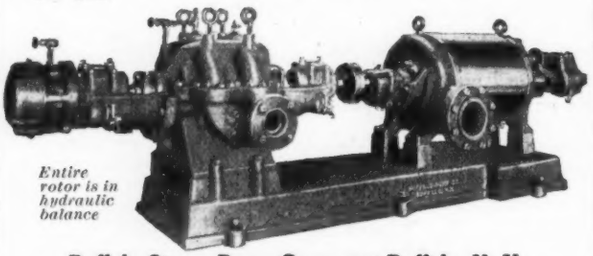

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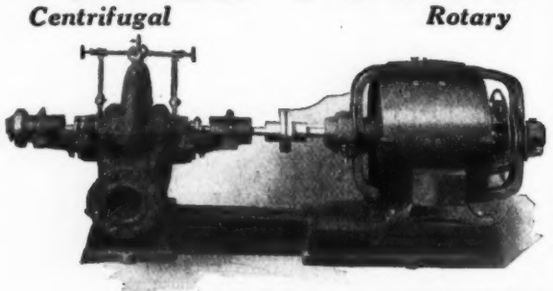

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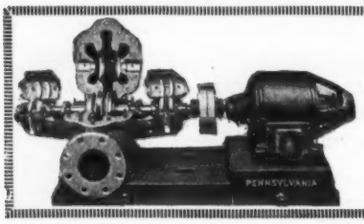

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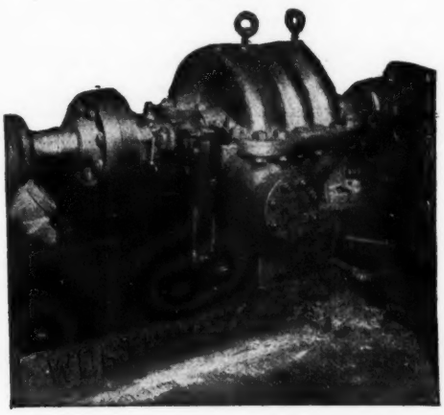
No. 10



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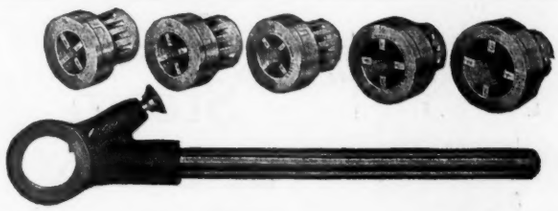

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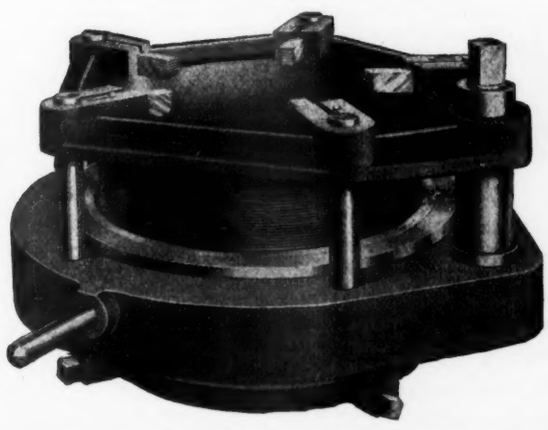

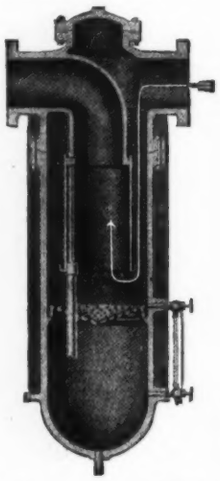

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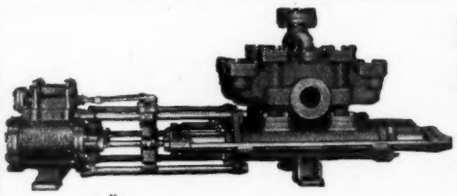

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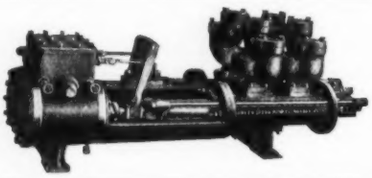

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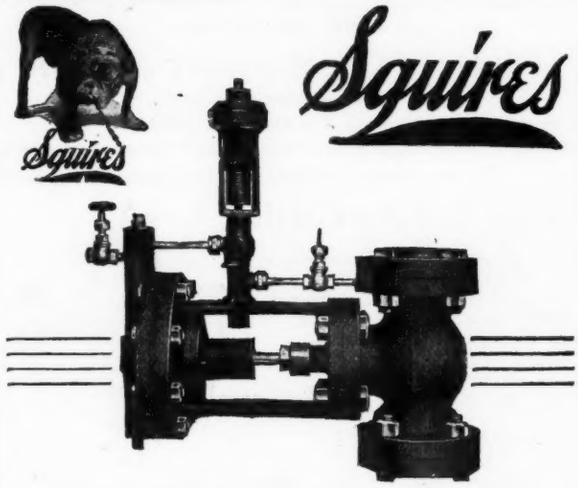

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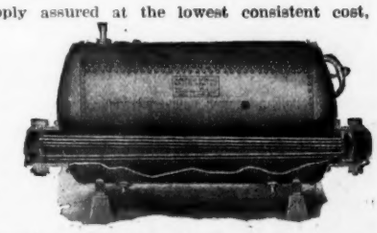

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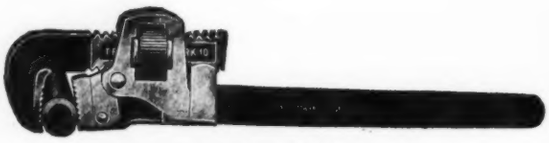

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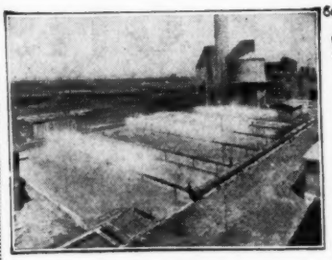

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The Powers Thermostatic Water Controller is so perfect in mechanism that overheated water cannot pass through it.

It is thermostatically controlled—not a "mixer." For individual or gang showers, hot water lines, etc.

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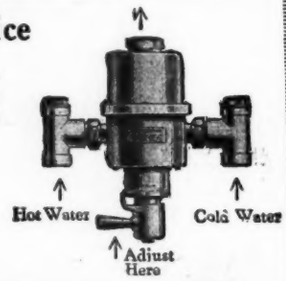

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Specialists in Automatic Heat Control

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Recording, Indicating and Dial Thermometers, Gauges for Pressure, Vacuum and Draft, Calorimeters, Barometers, Tachometers, Tachoscopes, Counters, Gauge Boards, etc. *Guaranteed accurate.* **Write for catalog No. N-32**

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Steam Separators
Oil Separators
Steam Traps
Exhaust Heads
Strainers
Air Traps
Boiler Alarm Water Columns
Boiler Feed Water Regulators
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Automatic Receiver Pumps
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REFRIGERATING AND ICE MAKING MACHINERY—WATER TUBE & HORIZONTAL RETURN TUBULAR BOILERS DROP FORGED STEEL VALVES & FITTINGS—OIL REFINERY EQUIPMENT—*Ask for Bulletins*

HENRY VOGT MACHINE CO., Manufacturers, Louisville, Ky.

Steam Trap SARCO Costs ⅔ less Guaranteed!

Sent on 30 days free trial
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Distilled Water for Boiler Make Up Feed

By the Lillie Apparatus

Adopted by U. S. Navy for its Ships

LILLIE Evaporators

Supplied only by
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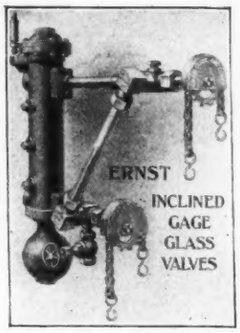

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Gage Glass can be set at any angle

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High Pressure Try Cocks
Are Different From All Others
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Softeners & Filters

Iron and Oil Removal Apparatus—Filtration Equipment—Water Conditioning Apparatus of every description

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Reducing Valves

will reduce the boiler pressure to any lower pressure required and will hold that pressure constant under all conditions.

Equally adapted to reduce water, air or gas pressure.

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APPARATUS FOR CONTROLLING FROM STEAM DEMAND
- STACK DAMPERS
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- FURNACE PRESSURE
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OPERATES FROM STEAM DEMAND

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SOLD ON MERIT – NOT PRICE

THE HAGAN SYSTEM
consists of special apparatus which regulates fuel supply, air supply and discharge of gases from Steam Demand and distributes the air to the individual furnaces in accordance with fuel bed conditions
SPECIAL SYSTEMS FOR BLAST FURNACE GAS AND POWDERED COAL

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Steam Traps

They return condensate *nearly as hot as steam* direct to the boilers. *Write* for descriptive matter.

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10-15% FUEL SAVED IN OVER 8,000 INSTALLATIONS AGGREGATING MORE THAN 5,000,000 H.P.

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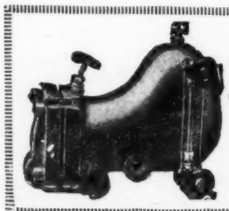
FEED WATER HEATER
WARREN WEBSTER AND COMPANY, CAMDEN, N.J.



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CONTINUOUS OPERATION
without Steam Leakage
Write for information

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The inverted submerged principle gives:
Greater capacity than any trap of equal size. Self-scrubbing. Cannot pass steam, action quick and positive. Non air-binding. Small size. Low cost.

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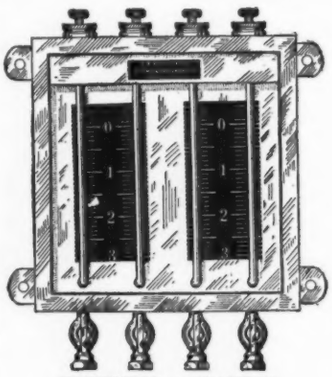
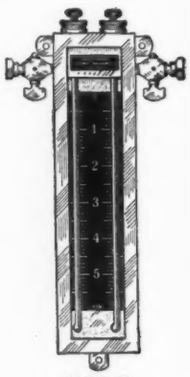


DEFENDER 4 CHAMBER



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Defender Direct-reading Vertical Pressure Gauges

For reading the pressure in the blast on forced-draft underfeed and chain-grate stokers.

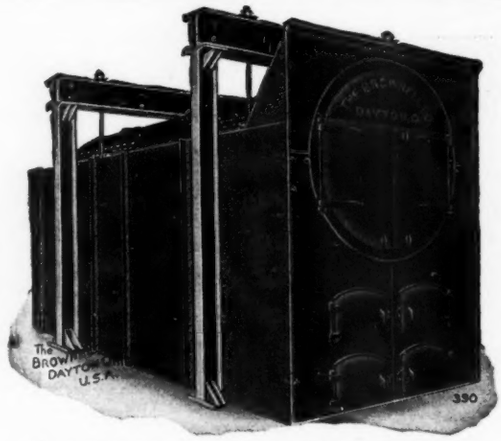
Built with single, duplex, and with any number of gauges and any length of scales or combinations of scales in the same case.

The Single and Duplex Gauges are furnished with side connections, and the multiple types from three chambers up have bottom connections. These are a big advantage over the top connections.

All the oil chambers, which are at the back of the case, are equipped with oil leveling plungers, ½ in. in diameter and 2 in. long. A fraction of a turn on these plungers allows each gauge to be leveled in a second's time. Once a year is enough to fill the gauges with the red oil. Ask for Bulletin No. 105.

The Defender new general Catalog, No. 14, is now ready. It shows a full line of all types of Draft Gauges, suited for all types of boilers, fuels, drafts, etc.; also Damper and Stoker Regulators, CO_2 Orsats and Recorders, Thermometers, Recording Draft and Pressure Gauge, Portable Boiler Room Test Outfits, Water-gauges, and Gauge Cocks, etc.

DEFENDER AUTOMATIC REGULATOR COMPANY
St. Louis, Mo.



Brownell Horizontal Tubular Boiler and Steel Casing

Brownell Power Plant Equipment has been on the market since 1855 and is designed and built on a strictly high quality basis in many standard types that will meet the requirements of the modern isolated industrial, municipal, and institutional plant.

The Steel Casing Setting with Brownell Horizontal Tubular Boiler is a most economical installation. Increased draft and boiler efficiency, decreased maintenance costs, improved boiler room appearance, are the positive results obtained from the steel casing.

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Steam and Oil Separators and Exhaust Heads
Catalog No. 70 on request

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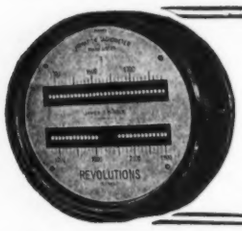

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is recognized by engineers as absolutely "*the best*" speed indicator for permanent attachment to steam turbines or other prime movers which operate between 900 and 8000 r.p.m. No belt, gears or electrical connections are necessary. Used by U. S. Government and all standard turbine builders.

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Safety Water Columns

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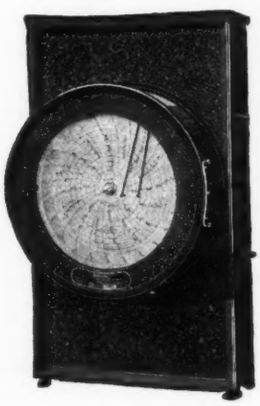
REPUBLIC

ONLY ELECTRICALLY OPERATED

FLOW METERS



Model "SFC"

A device which simultaneously shows the steam output and CO_2 on one chart, so that coal saving comparisons can be conveniently made. Ask for catalog.

Find the *cause*— and the cure is simple

BEFORE you can know what equipment you need—before you can take steps to eliminate waste—*you must know the cause of the waste.* An engineer who tries to stop waste, without definite records of all possible sources of loss, is like a doctor who attempts to cure an ailment that he can't diagnose.

Flow meters and CO_2 recorders show the symptoms of power plant waste, so that losses may be detected and intelligent steps taken to eliminate them with the least possible expenditure for new equipment. For this reason steam flow and CO_2 records are economically indispensable.

The Republic Model "SFC"

simultaneously makes graphs of both of these dollar saving records.

Informative comparisons are thus put before the operator in the most understandable form.

Ask for special bulletin explaining how this device lays a finger on the *cause* of loss, and why the Republic principle of electrical flow meter operation insures an unapproached degree of accuracy.

REPUBLIC FLOW METERS CO

2240 DIVERSEY PARKWAY

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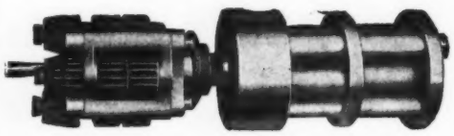
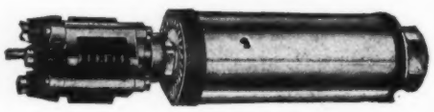
A Kind for Every Tube
Kind to Every Tube



Air Driven Cleaner for Fire Tube or Water Tube Boilers



Water Driven Cleaner for Water Tube Boilers, Fuel Economizers, Etc.

Cleaner for Curved Tubes Made in Either Air or Water Driven Types

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The Roto Company
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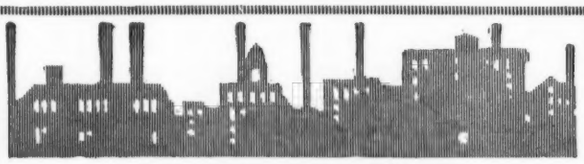
There's a *Tycos* or *Taylor* temperature instrument for every purpose

Taylor Instrument Companies



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has paved the way to many at greatly advanced salary and professional prominence. Complete—no extras needed—moderate price—very easy terms of payments.

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reduce fuel expense.

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W-R Continuous CO_2 Recorders will accurately record the percentage of CO_2 in the boiler exit gases to guide the firemen and to show the engineer how efficiently the boilers are being fired. No liquid chemical. Order one for every boiler. Write.

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One of the Esterline-Angus line of indicating and recording instruments.

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Measures hot and cold water, sewage, brine, chemical solutions, oil, gas, air and steam.
Bulletin on request

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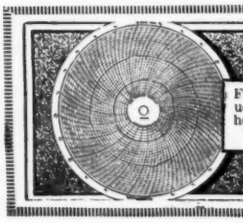

FOXBORO

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The Foxboro Co., Inc., Foxboro, Mass.

RECORDS

Things that will interest you

1. A new development in Compressed Air Separators.
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5. The value of employing the proper type of oil separator for your requirements.
6. Steam traps — and ways to save money.
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—and then you know why

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Take, for example, the data on feed water heaters. After you learn the reasons for their adaptability you will understand better why they were chosen for the great new General Motors Building in Detroit (the largest office building in the world).

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Saves You Money and Perhaps Your *Eyesight* from *Splintered Glass*

SONDERGLASS ends all gauge glass troubles, bursting glasses, cloudy glasses, etc.

Sonderglass remains perfectly clear indefinitely. The money spent for it is not looked upon as an expense but as a means to cut down needless gauge glass waste.

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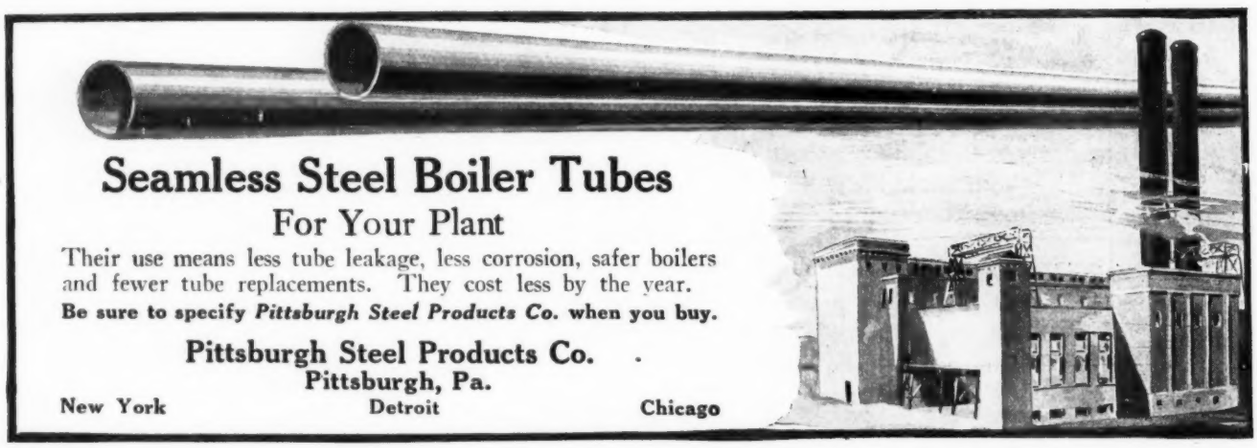

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For Your Plant

Their use means less tube leakage, less corrosion, safer boilers and fewer tube replacements. They cost less by the year.

Be sure to specify *Pittsburgh Steel Products Co.* when you buy.

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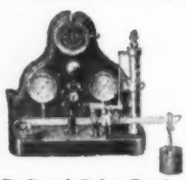

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Regulates—Coal—Air—Water
All the factors employed in the generation of steam
Saves—Coal—Furnaces—Boilers—Labor
This Coal Saving System should be in your plant. Let us tell you what it can do for you.

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A necessity for turbine protection, engine cylinder economy, and utilization of superheat for all its benefits

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The Logical Step Toward Economy—

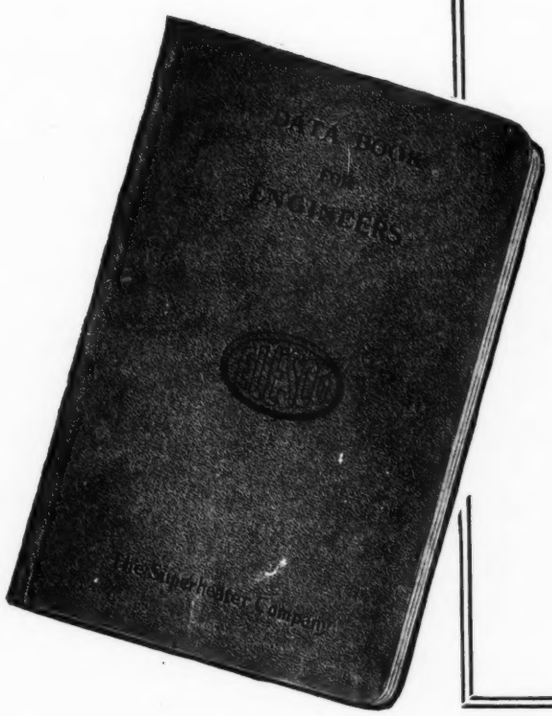
$$E = \frac{T_1 - T_2}{T_1}$$

In this well-known formula for the theoretical efficiency of a heat engine, the temperature of the steam coming to the engine or T_1, and the temperature of the heat rejected or T_2, can never be such as to make any steam engine 100% efficient.

By compounding, the value of T_2 is decreased, and with T_1 constant, the efficiency will be increased. T_2 may be further decreased by condensing.

By increasing boiler pressures, T_1 is increased and therefore higher efficiency results. However, as pressures are increased, for a relatively slow gain in T_1, practical difficulties are encountered in boiler design and maintenance.

The most logical and practical means for increasing the efficiency of an engine is to increase the value of T_1 by superheating. Furthermore, the use of superheated steam improves the operation of all parts of a power plant.



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DESIGNING ENGINEERS AND MANUFACTURERS OF ELESCO STEAM SUPERHEATERS AND PIPE COILS FOR ALL PURPOSES

FEED WATER HEATING EQUIPMENT FOR LOCOMOTIVE SERVICE; BOILER FEED PUMPS FOR ALL SERVICES; EXHAUST STEAM INJECTORS.

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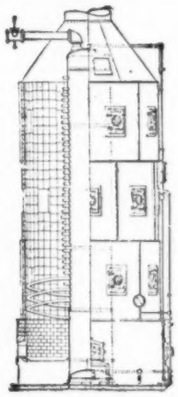

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that make steam at low cost

The high fire chamber of MORRIN-CLIMAX Vertical Tube Boilers effects a more perfect combustion of fuel, and the loop tubes afford best opportunity for heat absorption.

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Water Tube Boilers
Pulverized Coal Equipment

Write for bulletins

Erie City Iron Works, Erie, Pa.

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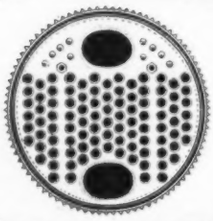

74% boiler efficiency, 150% overload without priming and 35% saving in floor space guaranteed.

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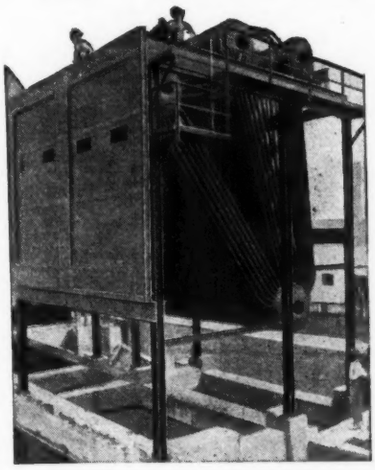

This picture shows a 1058-H.P. unit at Andrews Steel Co., Newport, Ky.

THE Connelly (patented) water tube boiler is so designed as to extract the most heat from the fuel, to provide for expansion and contraction, to eliminate to the highest possible degree all unnecessary joints, to entirely eliminate the use of staybolts, braces and crown bars. It is built in the most modern and best equipped boiler manufacturing plant in America, by a firm representing 46 years of experience, with the result of having a mechanism that gives the highest daily efficiency of operation.

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Founded in 1875 by Daniel Connelly

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Unexcelled in steaming economy and maintenance. Straight tubes—capacities to 3,000 hp. Write for catalog B. H.-20.

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Water Tube, Cross Drum, Return Tubular **Catalog of Either Type on Request**

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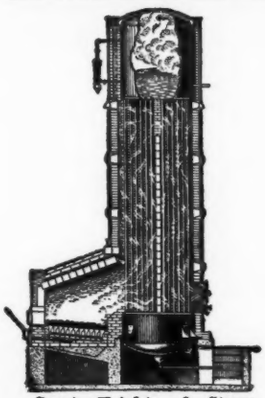
Branches: New York Philadelphia Boston Pittsburgh Chicago Buffalo



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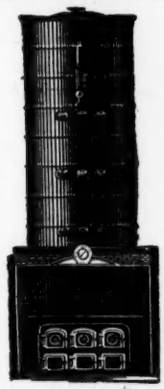

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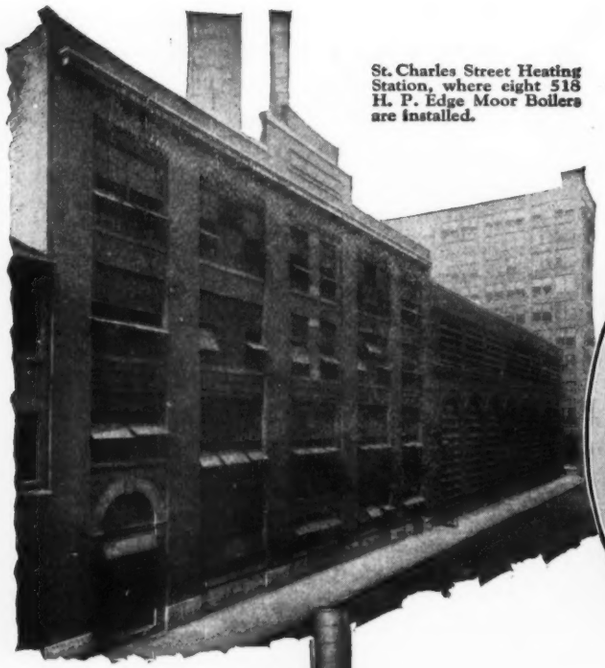
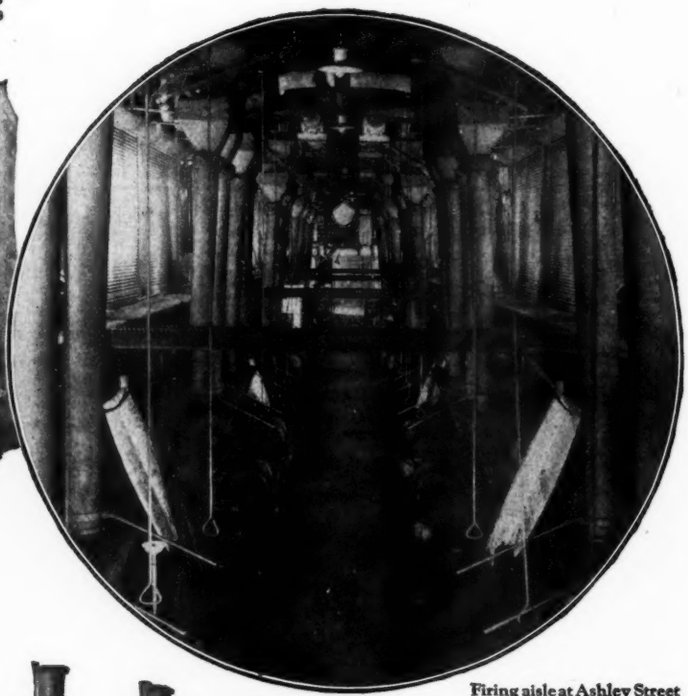
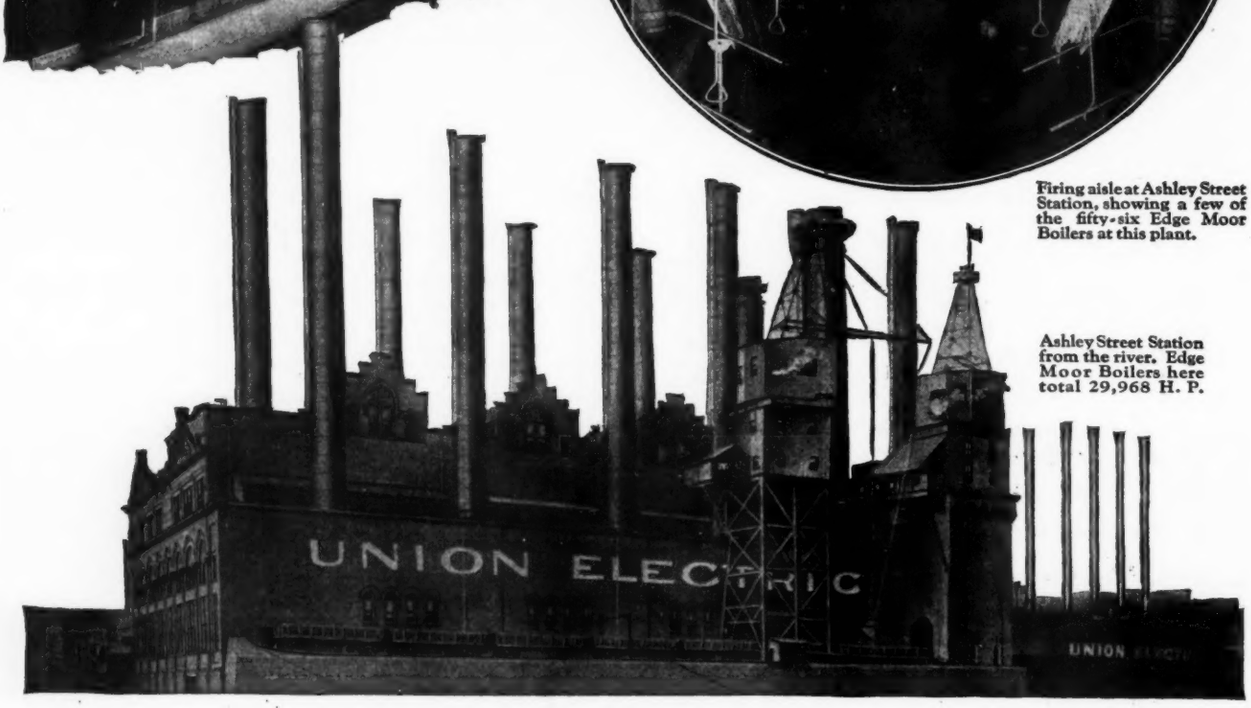


St. Charles Street Heating Station, where eight 518 H. P. Edge Moor Boilers are installed.



Firing aisle at Ashley Street Station, showing a few of the fifty-six Edge Moor Boilers at this plant.



Ashley Street Station from the river. Edge Moor Boilers here total 29,968 H. P.

EDGE MOOR

FOR INCREASED

Power Company Uses 64 Edge Moor Boilers

ANOTHER example of the ability of Edge Moor Water Tube Boilers to stand up under the difficult conditions of central station service is the installation at the Union Electric Light & Power Company, St. Louis.

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> "The boilers at the Heating Station were originally installed at the Ashley Street Station in 1906, and in 1917 were removed and erected in the Heating Station. Despite the age of these boilers, they are giving wonderful results both as to economy and capacity. Operating at 185 lbs. pressure, they frequently carry overloads of 200% of rating during the winter season.
>
> "The Edge Moor Boilers at the Ashley Station Street have also proven their adaptability and economy."

The new Edge Moor catalog contains much useful information for the power plant operator. We shall be glad to send a copy at your request.

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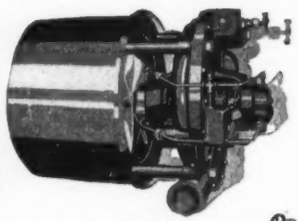

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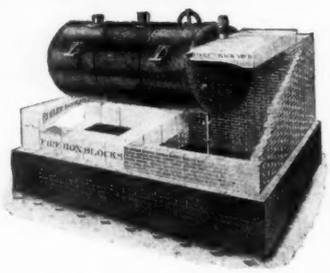

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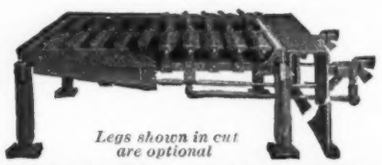

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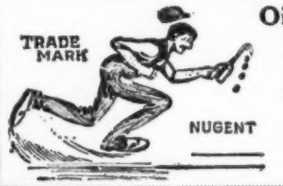

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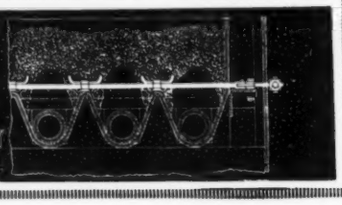

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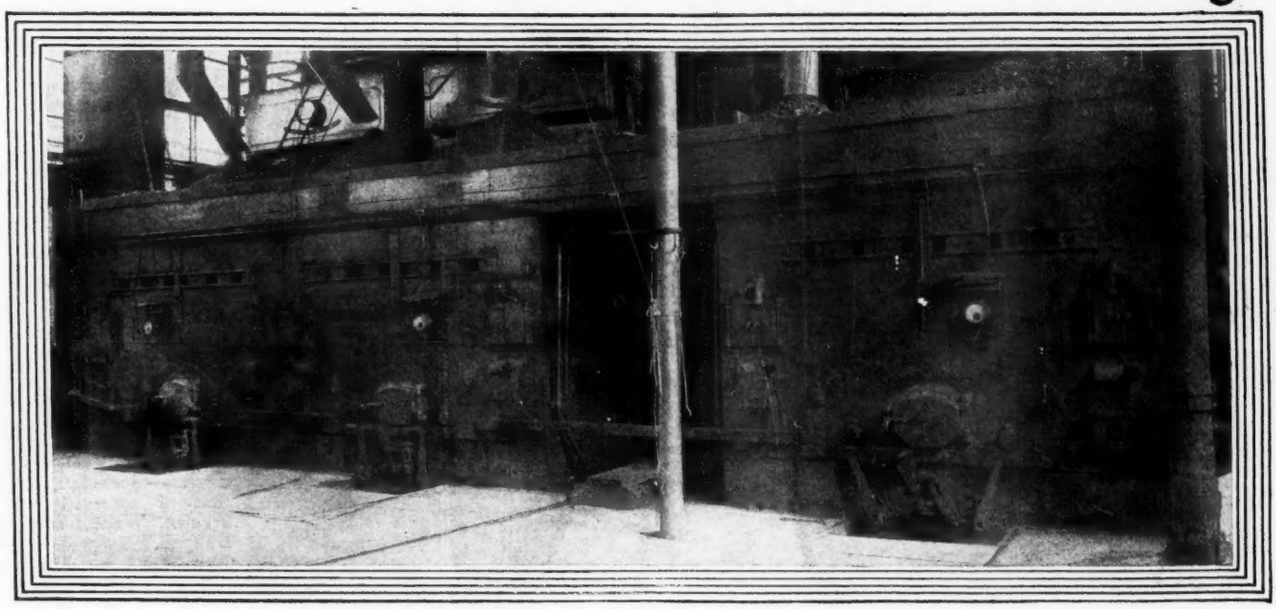

Many a good dollar which ought to go into the dividend pile, is flying up the smoke stacks of our industrial power plants.

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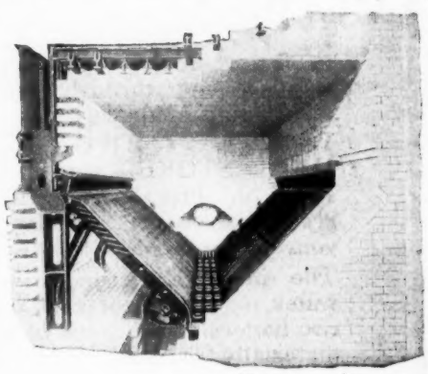

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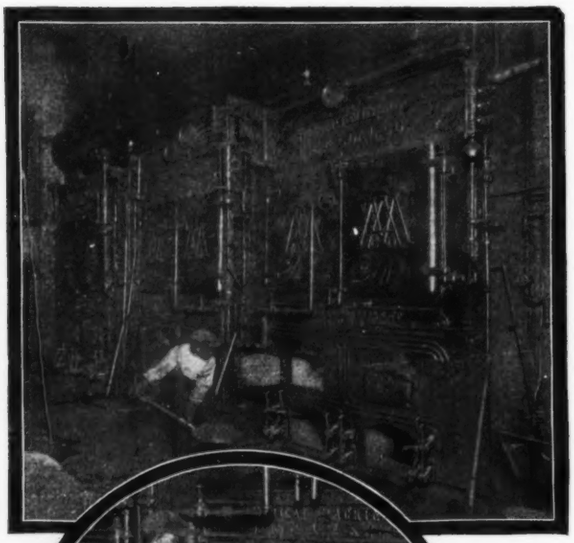
SAVE FUEL "DETROIT V TYPE STOKER" AND LABOR



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"Save Coal"

Vogt Brothers Hand Stoker

meets present-day demands for fuel economy through scientific combustion methods.

With VOGT BROTHERS HAND STOKER you not only save on fuel consumed, but greatly increase the efficiency of your power plant.

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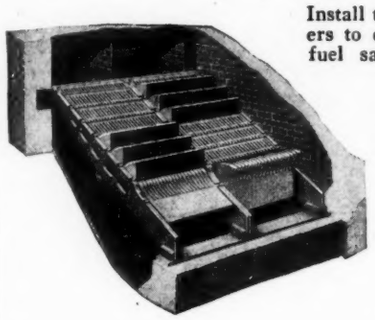

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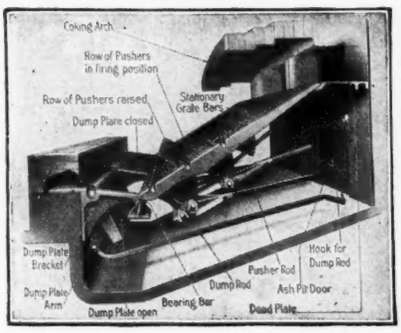

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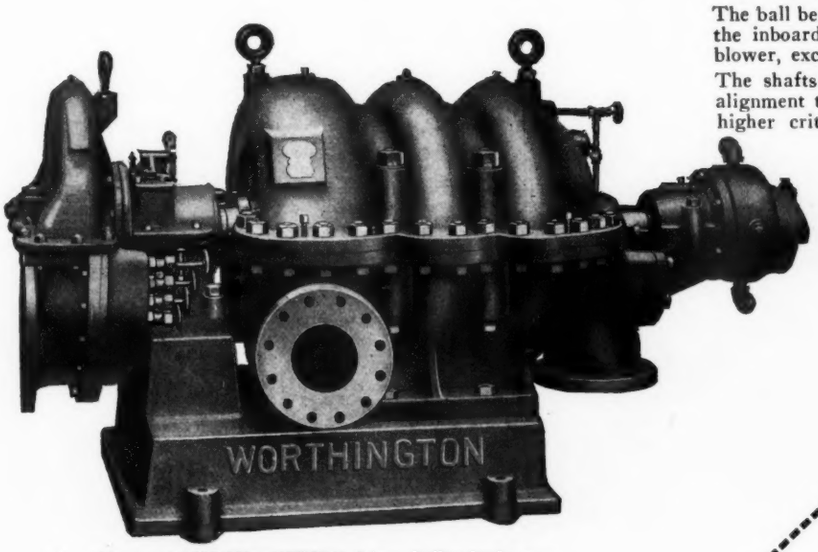

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Successors to Steam Motors Co.

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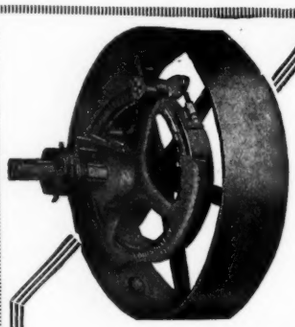

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STATIONARY 120 TO 3300 B.H.P.
MARINE 600 TO 3000 S.H.P.

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NEW YORK, 60 BROADWAY **SAN FRANCISCO. RIALTO BLDG.**

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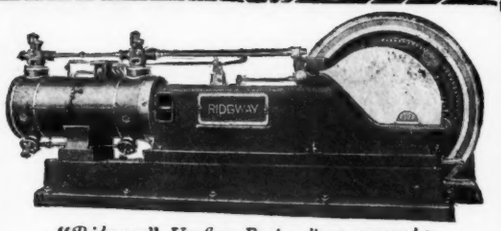

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"Ridgway" Power Units

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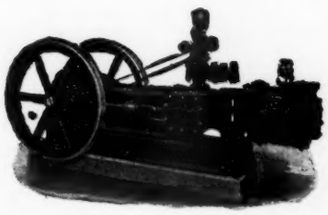

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C-102

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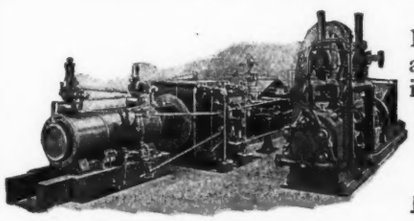

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is a big word among engineers and plant owners. For two generations it has never been surpassed. Self-compensating steam valves positively prevent that heavy leakage loss.

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We repair all makes of engines. Emergency service at your plant if required. Write

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For correct cylinder lubrication.
Saves 25 to 50 per cent in oil bills. **Write.**

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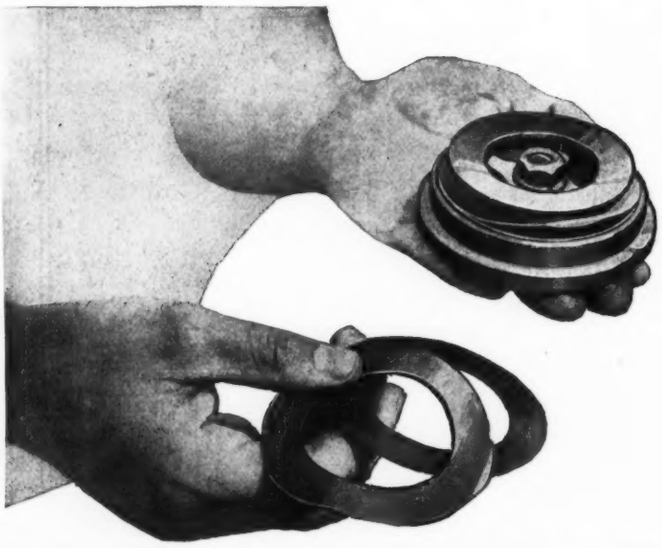
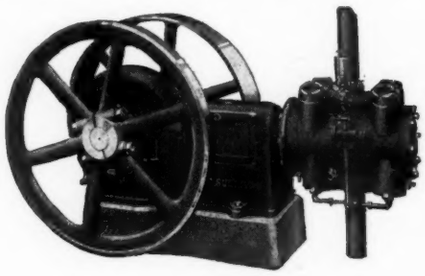
Sullivan Wafer Valves for WG-6 Compressors



LIGHT, thin steel discs, held to their seats by flat springs of the same material, form the valves of Sullivan WG-6 single stage belted Compressors.

Wide, short, port openings, lightness, low lift, simplicity and long life are "Wafer" valve features, which help to make the service rendered by these small Sullivan Compressors more efficient, more dependable, and more economical than ever.



The WG-6 has a heavy, one-piece frame, reducing foundation costs. It is belt driven from either side. It is of the center-crank type, and practically automatic. The WG-6 is splash-oiled and totally enclosed. An inlet valve unloader saves power when air is not needed. WG-6 Compressors are available in capacities of 50 to 510 cubic feet.

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They will show you how to figure clutch installations correctly.

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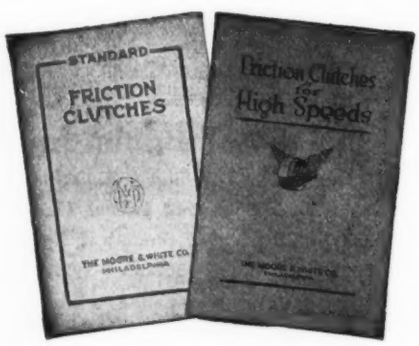

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Blowers Exhausters Injectors Ejectors
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GAS ENGINES
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and High Speed Vertical Steam Engines
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Heaviest of its class made and sold at reasonable prices. At your jobbers. Write for Catalog.

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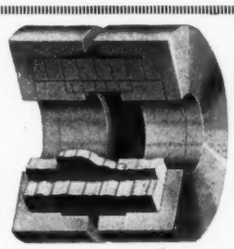

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Registered U. S. Patent Office

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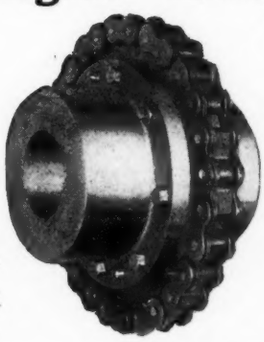
A MARK known and respected around the world — Since 1868 — for fair dealing, a quality product and an unexcelled service

Higher Efficiency For Your Direct Drives



Type "E," fitted with demountable Forged steel sprockets; perfectly interchangeable.

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CLARK Flexible Couplings

They will freely compensate for all shaft misalignment, insuring smooth operation with the maximum power transmission. The design is different. It consists of two sprockets held together by a roller chain which transmits the power from one to the other.
Positively dependable and entirely adapted to all light and heavy drives, at all speeds. Can be run in oil bath.
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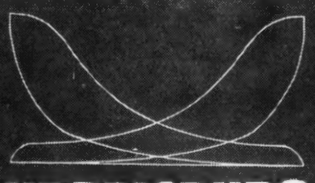

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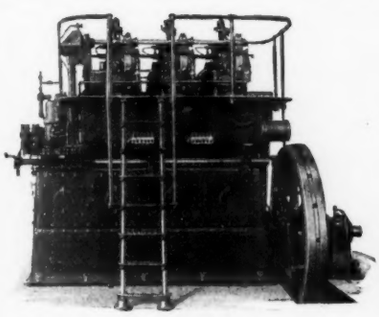

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Require No Attention

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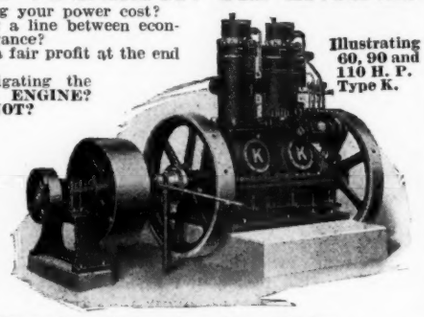
The Problem of fuel, labor, and maintenance cost in plants seem insolvable—and in many cases will remain insolvable — until steps are taken to eliminate unnecessary waste by installing the **ANDERSON OIL ENGINE.**



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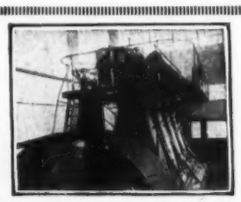

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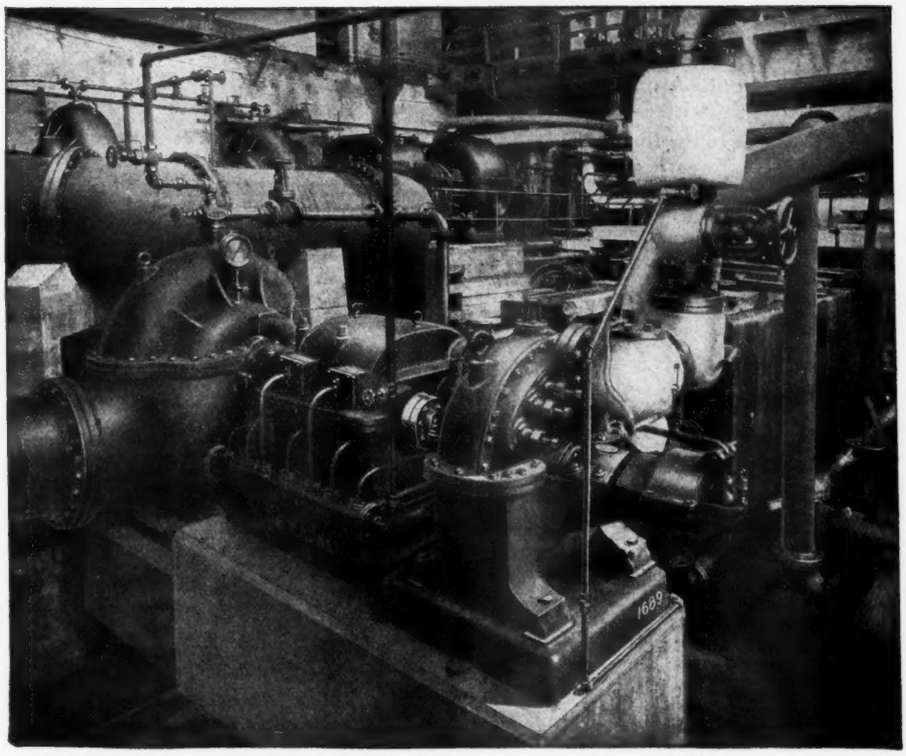
KERR TURBINE COMPANY **WELLSVILLE, N. Y.**



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Trenton, New Jersey

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221

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Equipment, Apparatus and Supplies Used in the Power Plant Field with Names of Manufacturers and Distributors

Please refer to the Buying Section for addresses of concerns listed in this directory.
See Last Page for Alphabetical Index

Aftercoolers and Receivers, Air
Chicago Pneumatic Tool Co.

Alarms, Low Water
Elliott Co.
Lunkenheimer Co.
Reliance Gauge Column Co.
Wright-Austin Co.

Alternators, Turbo
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Kerr Turbine Co.
Moore Steam Turbine Corp.
Ridgway Dynamo & Engine Co.
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(See Coal and Ash Handling Machinery)

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Blowers, Induced Draft
Coppus Eng'g & Equip. oo.

Blowers, Steam Jet
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Coppus Eng'r'g & Equip. Co.
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(See Cleaners, Boiler Tube)

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Hagan Corp.
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Hunt Co., C. W.
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Condensers, Jet
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American District Steam Co.
Johns-Manville, Inc.

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Conveyors Corp. of America

Conveyors, Coal and Ash
(See Coal and Ash Handling Machinery)

Conveyors, Soot
Conveyors Corp. of America

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Smith & Serrell
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Orton & Steinbrenner Co.

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Underwood Corp., H. B.

Cut-Outs, Electric
Johns-Manville, Inc.

Cutters, Boiler Tube
(See Pipe Cutters)

Cylinder Boring Bars and Reboring
Underwood Corp., H. B.

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Clarage Fan Co.

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Underwood Corp., H. B.

Die Stocks
Toledo Pipe Theading Mach. Co.

Distilling Plants (Water)
Griscom-Russell Co.

Doors, Ash Pit
Conveyors Corp. of America
Green Engineering Co.

Draft, Mechanical
(See Blowers, Fan)

Dressing, Belt
Cling Surface Co.
Keystone Lubricating Co.
Rhoads & Sons, J. E.
Schieren Co., Charles A.

Dressing, Rope
Cling Surface Co.

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Dynamos (See Generators)

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Green Fuel Economizer Co.

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Elliott Company.

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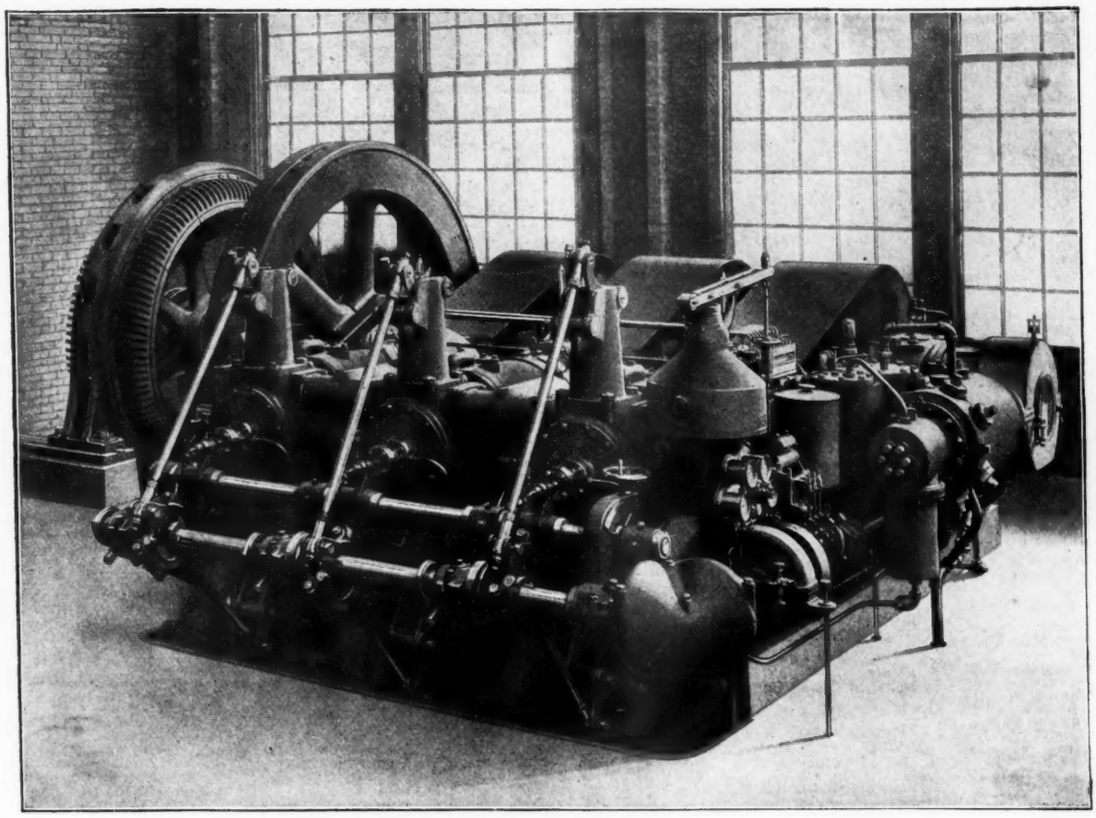
Eynon-Evans Corp.
Lunkenheimer Co.
Schutte & Koerting Co.
Sherwood Mfg. Co.

Electric Wires and Cables
American Steel & Wire Co.



Allis-Chalmers Triplex Oil Engine and Generator Unit.

Diesel Engine Drive

The high thermal efficiency of the Allis-Chalmers Diesel Engine and its special constructive features, together with the fact that it can be successfully used with any fuel oil that can be pumped, make it a particularly economical and desirable form of prime mover.

Complete electric power units Diesel engine driven and engines for either direct connected or belted service are designed and built by the Allis-Chalmers organization.

Send for Bulletin 1532-A

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MANUFACTURING COMPANY

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STEAM TURBINES — STEAM ENGINES
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Orton & Steinbrenner Co.

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Hadfield-Penfield Steel Co.
McIntosh & Seymour Corp.

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Hadfield-Penfield Steel Co.
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Ingersoll-Rand Co.

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(See Blowers, Fan)

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Elliott Co.
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Permutit Co.
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Reading Valve & Fittings Div.
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Detrick Co., M. H.
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Jointless Fire Brick Co.
King Refractories Co.
McLeod & Henry Co.

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Liptak Fire-Brick Arch Co.

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Detroit Stoker Co.
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(See Cocks, Gage)

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Ernst & Co.
Garlock Packing Co.
Rogers Co., H. A.

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Gages, Draft
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Bristol Co.
Brown Instrument Co.
Defender Automatic Regulator Co.
Foxboro Co.
Hays Corp., Jos. W.

Gages, Liquid Level
Foxboro Co.

Gages, Oil
Richardson-Phenix Division

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Bristol Co.
Foxboro Co.
Schaeffer & Budenberg Mfg. Co.

Gages, Recording
Bristol Co.
Foxboro Co.
Hays Corporation, Jos. W.

Gages, Vacuum
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Foxboro Co.
Greene, Tweed & Co.

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Greene, Tweed & Co.
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Reliance Gauge Column Co.

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Kerr Turbine Co.

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Terry Steam Turbine Co.

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Ridgway Dynamo & Engine Co.
Terry Steam Turbine Co.

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Buffalo Steam Pump Co.
Ridgway Dynamo & Engine Co.
Spray Engineering Co.

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Moore Steam Turbine Corp.
Terry Steam Turbine Co.
Westinghouse Elec. & Mfg. Co.

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Mason Regulator Co.
Northern Equipment Co.

Governors, Pump
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Hangers, Shafting
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Wheeler Cond. & Engr. Co.

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Godfrey Conveyor Corp.

Hoists, Air
Chicago Pneumatic Tool Co.

Hoists, Electric
Conveyors Corp. of America

Hoists, Portable, Air
Sullivan Machinery Co.

Hoists, Steam
Sullivan Machinery Co.

Hoppers, Coal and Ash
Conveyors Corp. of America
Green Engineering Co.
Jeffrey Mfg. Co.

Hose, Air
Chicago Pneumatic Tool Co.

Hose, Rubber
Goodrich Rubber Co., B. F.
New York Belting & Packing Co.
Quaker City Rubber Co.

Ice Machine Repairs
Underwood Corp., H. B.

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Indicators, Steam Engine
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Jenkins Bros.
Lunkenheimer Co.
Manzel Bros. Co.
Powell Co., Wm.
Sherwood Mfg. Co.

Leathers, Hydraulic and Cup
Schieren Co., Chas. A.

Leather Lace
Schieren Co., Chas. A.

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Westinghouse Elec. & Mfg. Co.

Lightning Rods
Custodus Chimney Constr. Co., Alphons

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Keystone Lubricating Co.
Sun Co.

Lubricators, Cylinder
Greene, Tweed & Co.
Keystone Lubricating Co.
Lunkenheimer Co.
Ohio Grease Co.
Powell Co., Wm.
Sherwood Mfg. Co.

Lubricators, Force Feed
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Ingersoll-Rand Co.
Lunkenheimer Co.
Powell Co., Wm.
Richardson-Phenix Division

Lubricators, Sight Flow
Richardson-Phenix Division

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Harrisburg Fdy. & Mach. Works
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Lammert & Mann Co.

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Builders Iron Foundry
Republic Flow Meters Co.

Meters, Boiler
Bailey Meter Co.
Esterline-Angus Co.
Republic Flow Meters Co.

Meters, Concentration
Esterline-Angus Co.

Meters, Coal
Bailey Meter Co.

Meters, Electric
Westinghouse Elec. & Mfg. Co.

Meters, Feed Water
Bailey Meter Co.
Builders Iron Fdry.
Republic Flow Meters Co.
Webster & Co., Warren
Yarnall-Waring Co.

Meters, Flow
Cory & Son, Inc., Chas.
Bailey Meter Co.
Builders Iron Fdry.
Republic Flow Meters Co.
Yarnall-Waring Co.

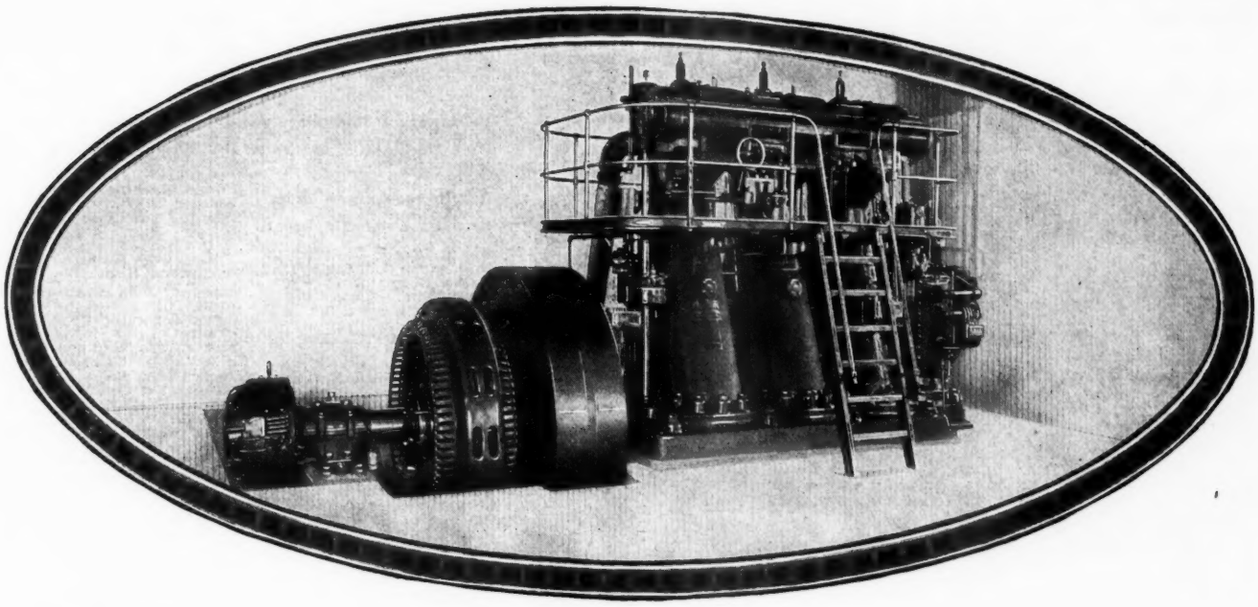
Meters, Gas
Bailey Meter Co.
Builders Iron Foundry
Republic Flow Meters Co.

Meters, Graphic
Esterline-Angus Co.

Meters, Oil
Builders Iron Foundry
Republic Flow Meters Co.

Meters, Steam
American District Steam Co
Bailey Meter Co.
Builders Iron Foundry
Republic Flow Meters Co.

Meters V-Notch
Bailey Meter Co.
Hoppes Mfg. Co.
H. S. B. W. Cochrane Corp.
Yarnall-Waring Co.



A Power Problem of Fuel Waste Solved

An end long sought by builders of prime movers is a power plant which operates at high efficiency at fractional loads—a plant with a fuel economy that is constant over all loads.

In the Fulton Diesel Oil Engine this great end is fully attained. Fuel consumption is reduced automatically in proportion to the load with only a negligible increase in consumption per net horsepower at any point in the entire range of load.

This fact makes the Fulton Diesel more economical in the use of fuel per net horsepower than any other type of prime mover. And this economy is independent of the human element, for, excepting the operations in starting and stopping, the engine is self-controlled and automatic in its functions.

Facts to Remember About the Fulton Diesel

A compact, self-contained power plant.
For all power purposes in units from 150 to 1000 horsepower.
In most cases shows clear savings of two-thirds over fuel consumption under boilers.
Thermal efficiency:
Steam—15% maximum.
Diesel—36% net.
Fuel consumption in direct proportion to load.
Uses cheap fuel.
Constant readiness for operation without stand-by losses.
Quick and easy starting.
Economy independent of size.
Long life with constant efficiency.
Easily operated and maintained by any competent steam engineer.

Our new Bulletin, No. 801, describing and illustrating the Fulton Diesel Engine and containing other valuable information, will be mailed upon request.

FULTON IRON WORKS COMPANY, ST. LOUIS, U.S.A.

Successful Engine Builders for 69 Years

BRANCH OFFICES: New York, 82 Wall St.; Cuba, Havana, 401-402 Banco Nacional

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Hoppes Mfg. Co.
Republic Flow Meters Co.
Yarnall-Waring Co.

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Electric Machinery Mfg. Co.
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Sun Co.

Oil, Fuel
Sun Co.

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Lunkenheimer Co.
Ohio Grease Co.
Powell Co., Wm.

Oil, Lubricating
Cook's Sons, Adam
Sun Co.

Oil Reclaimers
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Richardson-Phenix Division

Oilers, Telescopic & Centrifugal
Richardson-Phenix Division

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Richardson-Phenix Div.

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Sarco Co.

Packing, Cylinder
Rooksby & Co., E. J.
Chesterton Co., A. W.

Packing, Hydraulic
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Chesterton Co., A. W.
Crandall Packing Co.
Garlock Packing Co.
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Schieren Co., Charles A.
Walker & Co., Ltd., Jas.

Packing, Leather
Schieren Co., Charles A.

Packing, Metallic
Crandall Packing Co.
France Packing Co.
Garlock Packing Co.
N. Y. Belting & Packing Co.
Walker & Co. Ltd., Jas

Packing, Piston
Chesterton Co., A. W.
Goodrich Rubber Co., B. F.
Johns-Manville, Inc.

Packing, Pump Valve
Garlock Packing Co.
Goodrich Rubber Co., B. F.
Johns-Manville, Inc.

Packing, Rod
Chesterton Co., A. W.
Crandall Packing Co.
France Packing Co.
Garlock Packing Co.
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Greene, Tweed & Co.
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Garlock Packing Co.
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Garlock Packing Co.
New York Belting & Packing Co.

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Plant Communication System
Cory & Son, Inc., Chas.

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Erie City Iron Wks.
Jeffrey Mfg. Co.

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Wheeler Mfg. Co., C. H.

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Manistee Iron Works Co.
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Terry Steam Turbine Co.
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Buffalo Steam Pump Co.
Coppus Engr. & Equip. Co.
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Ingersoll-Rand Co.
Kerr Turbine Co.
Lea Courtney Co.
Manistee Iron Works Co.
Morris Machine Works
Pennsylvania Pump & Compressor Co.
Taber Pump Co.
Twinvolute Pump Co.
Worthington Pump & Machy. Corp.

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Terry Steam Turbine Co.
Wright-Austin Co.

Pumps, Deep Well
Vacuum Oil Co.

Pumps, Elevator
Lea Courtney Co.
McGowan Co., J. H.

Pumps, Fire
Lea Courtney Co.

Pumps, Force Feed (See Lubricators)

Pumps, Mine
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Manistee Iron Works Co.

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Sherwood Mfg. Co.
Worthington Pump & Machy. Corp.

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Warren Steam Pump Co.

Pumps, Rotary
Taber Pump Co.

Pumps, Steam
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McGowan Co., J. H.
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Pennsylvania Pump & Compressor Co.
Warren Steam Pump Co.
Worthington Pump & Machy. Corp.

Pumps, Turbine
Allis-Chalmers Co.
Kerr Turbine Co.
Manistee Iron Works Co.
Terry Steam Turbine Co.

Pumps, Vacuum
Davidson Co., M. T.
Dean Bros., Steam Pump Works
Ingersoll-Rand Co.
Manistee Iron Works Co.
Pennsylvania Pump & Compressor Co.
Sullivan Machinery Co.
Warren Steam Pump Co.
Wheeler Mfg. Co.

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Lea Courtney Co.
Kerr Turbine Co.
Manistee Iron Works Co.
Twinvolute Pump Co.

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Foxboro Co.

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Permutit Co.
Webster & Co., Warren
Yarnall-Waring Co.

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Brown Instrument Co.
Hays Corp., Jos. W
Taylor Instrument Co.

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Vilter Mfg. Co.
Vogt Machine Co., Henry
York Mfg. Co.

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Defender Automatic Regulator Co.
Hagan Corp.
McDonough Coal Saving Corp.
Mason Regulator Co.
Power Turbo Blower Co.
Robertson & Sons, Jas. L.
Webster & Co., Warren
Wing Mfg. Co., L. J.

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Hagan Corp.

Regulators Feed Water
Elliott Co.
McDonough Coal Saving Corp.
Mason Regulator Co.
Northern Equipment Co.
Squires Co., C. E.
Wing Mfg. Co., L. J.
Wright-Austin Co.

Regulators, Gas
Hagan Corp.
Mason Regulator Co.

Regulators, Pressure
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Chaplin-Fulton Mfg. Co.
Crane Co.
Davis Regulator Co., G. M.
Elliott Co.
Engineer Co.
Hagan Corp.
Mason Regulator Co.
Squires Co., C. E.
Strong, Carlisle & Hammond Co.
Taylor Instrument Co.
Watson & McDaniel Co.

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Hagan Corp.
Mason Regulator Co.
Northern Equipment Co.
Squires Co., C. E.
Strong, Carlisle & Hammond Co.

Regulators, Stoker
Cash Co., A. W.
Hagan Corp.
Mason Regulator Co.

Regulators, Temperature
Bristol Co.
Foxboro Co.
Hagan Corp.
Powers Regulator Co.
Sarco Company

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Coatesville Boiler Wks.
Elliott Co.

Regulators, Vacuum
Mason Regulator Co.

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American Mfg. Co

Rope Transmission
American Mfg. Co
Hunt Co., C. W.

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Quaker City Rubber Co.

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Jeffrey Mfg. Co.

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Elliott Co.
Ohio Body & Blower Co.
Strong, Carlisle & Hammond Co.
United Machine & Mfg. Co.
York Mfg. Co.

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Direct Separator Co.
Elliott Co.
Griscom-Russell Co.
H. S. B. W. Cochrane Corp.
Hoppes Mfg. Co.
National Pipe Bending Co.
Ohio Body & Blower Co.
Robertson & Sons, Jas. L.
Strong, Carlisle & Hammond Co.
United Machine & Mfg. Co.
Webster & Co., Warren
Wright-Austin Co.

Separators, Steam
American District Steam Co.
Crane Co.
Direct Separator Co.
Elliott Co.
Griscom-Russell Co.
H. S. B. W. Cochrane Corp.
Hoppes Mfg. Co.
Nicholson & Co., W. H.
Patterson-Kelley Co.
Robertson & Sons, Jas. L.
Strong, Carlisle & Hammond Co.
United Machine & Mfg. Co.
Webster & Co., Warren
Wright-Austin Co.

Separators, Air
Direct Separator Co.
Elliott Company.
Griscom-Russell Co.
Ohio Body & Blower Co.

Sewerage Ejectors
Blackburn-Smith Corp.

Shafting
Cresson-Morris Co.
Valley Iron Works

Silencers, Exhaust
Maxim Silencer Co.

Skimmers, Boiler
Yarnall-Waring Co

Spray Nozzles (See Cooling Plants and Ponds)

Stacks, Metal
Heine Boiler Co.
Keeler Co., E.
Littleford Bros.
Morrin Climax Boiler Co.

Stacks, Radial Brick
American Chimney Corp.
Custodus Chimney Constr. Co,. Alphons

Stair Treads, Non Slipping
Irving Iron Works Co.

Steam Eliminators
Nicholson & Co., W. H.

Steam Turbine Electric Generating Sets
Kerr Turbine Co.
Terry Steam Turbine Co.

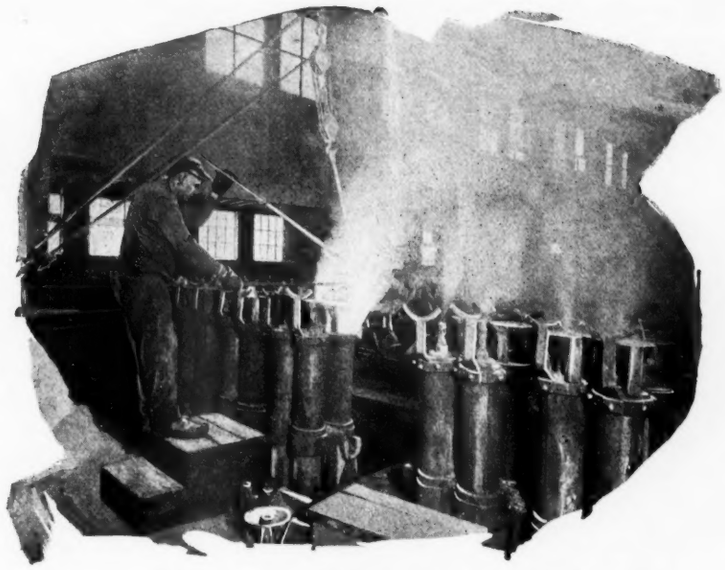
Steel Plate Work
Erie City Iron Wks.
Heine Boiler Co.

Stokers, Chain and Traveling Grate
Babcock & Wilcox Co.
Brady, James A., Foundry Co.
Combustion Engineering Corp.
Green Engineering Co
Illinois Stoker Co.
United Machine & Mfg. Co.

Stokers, Hand Operated
Cokal Stoker Corporation
Flynn & Emrich
Gibby Engineering Co.
Hofft Co., M. A.
Marion Machine Foundry & Supply Co.
McClave-Brooks Co.
Perfection Grate & Supply Co.
Valley Iron Works
Vogt Bros. Mfg. Co.

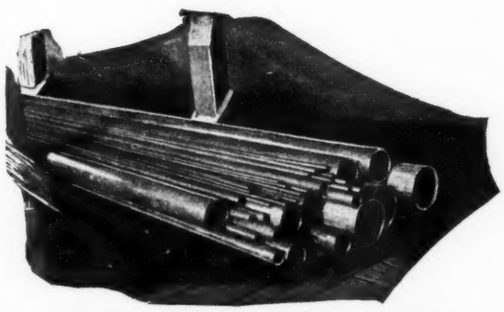
CHASE CONDENSER TUBES

—a product of careful skill and extraordinary manufacturing facilities



Chase condenser tubes are cast in the shell or rough tube which is later drawn down to the required size.

Tube
Rod
Wire
Sheet



Chase tubes are made in almost every size.

The South Meadow station of the Hartford Electric Light & Power Company is one of the many recent power plants who have chosen Chase condenser tubes because of their reputation of long service and quality.

Made in one of the largest and best equipped brass mills in the world by the most advanced processes of manufacture, where rigid tests and inspections watch every step, Chase Condenser Tubes give utmost satisfaction.

Specify Chase Brass

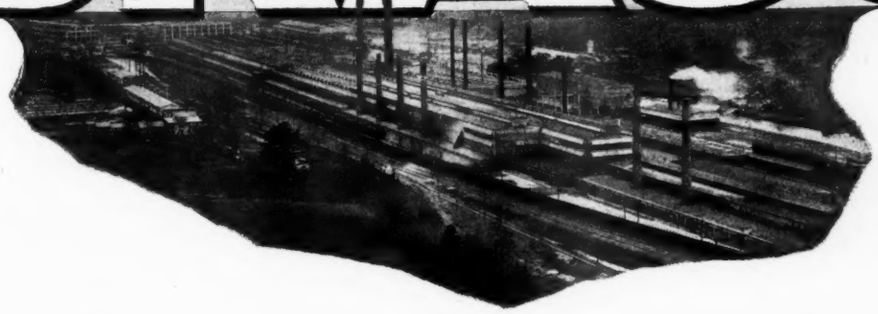
CHASE METAL WORKS

Division of Chase Companies Inc.
WATERBURY CONNECTICUT

PLANTS
CHASE METAL WORKS — Trade CHASE Mark — CHASE ROLLING MILLS

New York Rochester Boston Chicago Philadelphia
Detroit Cleveland Pittsburgh
The Chase Companies of California
San Francisco Los Angeles
The Ohio Chase Company, Cleveland

BRASS



Stokers, Overfeed, Front Inclined and "V" Types
Detroit Stoker Co.
McClave-Brooks Co
Murphy Iron Works
Westinghouse Elec. & Mfg. Co.

Stokers, Underfeed, Multiple Retort
American Engineering Co.
Detroit Stoker Co.
Riley Stoker Co., Sanford
Underfeed Stoker Co. of America
Westinghouse Elec. & Mfg. Co.

Stokers, Underfeed, Single Retort
Combustion Engineering Corp.
Detroit Stoker Co.
Roach Stoker Co.
Underfeed Stoker Co. of America

Strainers, Oil
Elliott Co.
Griscom-Russell Co.
Mason Regulator Co.
Richardson-Phenix Division

Strainers, Pump Suction
Elliott Co.
Webster & Co., Warren

Strainers, Steam
Wright-Austin Co.

Strainers, Water
Elliott Co.
Mason Regulator Co.

Superheaters
Babcock & Wilcox Co.
Foremost Engineering Corp.
Heine Boiler Co.
Power Specialty Co.
Superheater Co.

Switchboards
Westinghouse Elec. & Mfg. Co.

Switches and Circuit Breakers, Electric
Westinghouse Elec. & Mfg. Co.

Tachometers
Biddle, James G.
Foxboro Co.
Schaeffer & Budenberg Mfg. Co.

Tank and Grate Work
Lebanon Boiler Works
Petty & Co., J. K.
Union Iron Works

Tanks
Brownell Co.
Caldwell Co., Inc., W. E.
Conveyors Corp. of America
Davis & Sons Co., J. F.
Delany & Co., P.
Erie City Iron Works
Green Engineering Co.
Heine Boiler Co.
Lebanon Boiler Works
Morrin Climax Boiler Co.
Newburgh Steam Boiler Wks.
Petty & Co., J. K.
Tokheim Oil Tank & Pump Co.
Union Iron Works
Wright-Austin Co.

Thermometers
Bristol Co.
Hays Corp., Jos. W.
Taylor Instrument Co's.

Thermometers, Flue Gas
Bailey Meter Co.

Thermometers, Recording
Bailey Meter Co.
Foxboro Co.
Taylor Instrument Co's.

Transformers
Westinghouse Elec. & Mfg. Co.

Transmission Machinery
(See Power Transmission Machinery)

Traps, Compressed Air
Armstrong Machine Works

Traps, Grease
Armstrong Machine Works
Wright-Austin Co.

Traps, Non-Return
Armstrong Machine Works
Bundy Steam Trap Co.
Wright-Austin Co.

Traps, Radiator
Armstrong Machine Works
Sarco Company
Webster & Co., Warren

Traps, Return
Bundy Steam Trap Co.
Morehead Mfg. Co.
Strong, Carlisle & Hammond Co., The
Templeton Mfg. Co.
Wright-Austin Co.

Traps, Steam
American District Steam Co.
Armstrong Mach. Works
Bundy Steam Trap Co.
Crane Co.
Elliott Co.
H. S. B. W. Cochrane Corp.
Jenkins Bros.
Johns-Manville, Inc.
Morehead Mfg. Co.
Nicholson & Co., W. H.
Reliance Gauge Column Co.
Sarco Company
Schutte & Koerting Co.
Squires Co., C. E.
Strong, Carlisle & Hammond Co.
Watson & McDaniel Co.
Webster & Co., Warren
Wright-Austin Co.

Traps, Vacuum
Armstrong Machine Works
Bundy Steam Trap Co.
Morehead Mfg. Co.
Sarco Company
Strong, Carlisle & Hammond Co., The
Templeton Mfg. Co.
Webster & Co., Warren
Wright-Austin Co.

Traps, Variable Pressure
Wright-Austin Co.

Trolleys, I-Beam
Conveyors Corp. of America

Tube Cleaners, Boiler
(Cleaners, Boiler Tube)
(See Soot Blowers)

Tube Cleaners, Condenser
Lagonda Mfg. Co.

Tube Cutters
Lagonda Mfg. Co.

Tubes, Charcoal Iron
Parkesburg Iron Co.

Tubes, Condenser
Chase Companies.

Tubing
Boiler Tube Co. of Am.

Tubing, Condenser
Wheeler Condenser & Eng'g Co.

Turbines, Steam
Allis-Chalmers Mfg. Co.
Coppus Eng. & Equip. Co.
De Laval Steam Turbine Co.
Green Fuel Economizer Co.
Kerr Turbine Co.
London Steam Turbine Co.
Moore Steam Turbine Corp.
Power Turbo Blower Co.
Ridgway Dynamo & Engine Co.
Terry Steam Turbine Co.
Westinghouse Elec. & Mfg. Co.
Wing Mfg. Co., L. J.

Turbines, Water
Allis-Chalmers Mfg. Co.

Unions and Union Fittings
Crane Co.
Dart Mfg. Co., E. M.
Edward Valve & Mfg. Co.
Jefferson Union Co.
Lunkenheimer Co.
Richardson-Phenix Division

Valve Control, Electric
Dean, Payne, Ltd.

Valve Disc
Goetze Gasket & Pkg. Co.
Goodrich Rubber Co., B. F.
Jenkins Bros.
New York Belting & Packing Co.
Protected Seat Valve Co.

Valve Washers, Leather
Schieren Co., Charles A.

Valves, Ammonia
Chapman Valve Mfg. Co.
York Mfg. Co.

Valves, Angle
Protected Seat Valve Co.
Richardson-Phenix Division

Valves, Automatic Cutoff
Lagonda Mfg. Co.
Nelson Valve Co.
Protected Seat Valve Co.
Strong, Carlisle & Hammond Co.

Valves, Back Pressure
Chapman Valve Mfg. Co.
Davis Regulator Co., G. M.
H. S. B. W. Cochrane Corp.
Jenkins Bros.
Protected Seat Valve Co.

Valves, Balanced
Davis Regulator Co., G. M.
Mason Regulator Co.
Protected Seat Valve Co.

Valves, Blowoff
Chapman Valve Mfg. Co.
Crane Co.
Edward Valve & Mfg. Co.
Elliott Co.
Homestead Valve Mfg. Co.
Jenkins Bros.
Lunkenheimer Co.
Nelson Valve Co.
Powell Co., Wm.
Protected Seat Valve Co.
Yarnall-Waring Co.

Valves, Brass and Iron Body
Homestead Valve Mfg. Co.
Nelson Valve Co.
Pittsburgh Piping & Equipt. Co.
Protected Seat Valve Co.
Richardson-Phenix Division

Valves, Bypass
Chapman Valve Mfg. Co.
Jenkins Bros.
Lunkenheimer Co.
Mason Regulator Co.
Nelson Valve Co.
Protected Seat Valve Co.

Valves, Check
Chapman Valve Mfg. Co.
Davis Regulator Co., G. M.
Edward Valve & Mfg. Co.
Greene, Tweed & Co.
Jenkins Bros.
Lunkenheimer Co.
Nelson Valve Co.
Pratt & Cady
Protected Seat Valve Co.
Strong, Carlisle & Hammond Co.

Valves, Coal Bin
Conveyors Corp. of America
Green Engineering Co.
Jeffrey Mfg. Co.

Valves, Electrically Operated
Dean, Payne, Ltd.
Mason Regulator Co.
Nelson Valve Co.

Valves, Exhaust Relief
Chapman Valve Mfg. Co.
H. S. B. W. Cochrane Corp.
Jenkins Bros.
Protected Seat Valve Co.

Valves, Float
Davis Regulator Co., G. M.
Elliott Co.
Homestead Valve Mfg. Co.
Mason Regulator Co.
Yarnall-Waring Co.

Valves, Gate
Chapman Valve Mfg. Co.
Crane Co.
Greene, Tweed & Co.
Jenkins Bros.
Kennedy Valve Mfg. Co.
Lunkenheimer Co.
Nelson Valve Co.
New Bedford Valve Mfg. Co.
Pittsburgh Piping & Equipt. Co.
Powell Co., Wm.
Pratt & Cady
Protected Seat Valve Co.
Reading Valve & Fittings Div.

Valves, Globe and Angle
Crane Co.
Edward Valve & Mfg. Co.
Eynon-Evans Corp.
Homestead Valve Mfg. Co.
Jenkins Bros.
Kennedy Valve Mfg. Co.
Lunkenheimer Co.
Nelson Valve Co.
New Bedford Valve Mfg. Co.
Powell, Wm. Co.
Pratt & Cady
Protected Seat Valve Co.

Valves, Hydraulic
Chapman Valve Mfg. Co.
Homestead Valve Mfg. Co.
Pittsburgh Piping & Equipt. Co.
Protected Seat Valve Co.
Schutte & Koerting Co.
Vogt Machine Co., Henry
Yarnall-Waring Co.

Valves, Intake
Chapman Valve Mfg. Co.

Valves, Non-Return Stop
Chapman Valve Mfg. Co.
Edward Valve & Mfg. Co.
Jenkins Bros.
Lagonda Mfg. Co.
Lunkenheimer Co.
Nelson Valve Co.
Protected Seat Valve Co.
Schutte & Koerting Co.
Strong, Carlisle & Hammond Co.

Valves, Pop Safety
Crane Co.

Valves, Pump
Chapman Valve Mfg. Co.
Garlock Packing Co.
Jenkins Bros.
New York Belting & Packing Co.
Protected Seat Valve Co.
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Valves, Radiator
Webster & Co., Warren

Valves, Radiator Regulating
Webster & Co., Warren

Valves, Reducing
Atlas Valve Co.
Elliott Co.
Mason Regulator Co.
Protected Seat Valve Co.
Squires Co., C. E.
Strong, Carlisle & Hammond Co.
Watson & McDaniel Co.

Valves, Regrinding
Lunkenheimer Co.
Nelson Valve Co.
Pratt & Cady
Powell Co., Wm.

Valves Regulating
Defender Automatic Regulator Co.
Protected Seat Valve Co.
Squires Co., C. E.

Valves, Relief
Edward Valve & Mfg. Co.
Lunkenheimer Co.
Nelson Valve Co.
Protected Seat Valve Co.

Valves, Safety
Ashton Valve Co.
Jenkins Bros.
Lunkenheimer Co.
Protected Seat Valve Co.

Valves, Stop
Chapman Valve Mfg. Co.
Edward Valve & Mfg. Co.
Jenkins Bros.
Lunkenheimer Co.
Nelson Valve Co.
Protected Seat Valve Co.

Valves, Superheated Steam
Chapman Valve Mfg. Co.
Edward Valve & Mfg. Co.
Homestead Valve Mfg. Co.
Jenkins Bros.
Lunkenheimer Co.
Nelson Valve Co.
Protected Seat Valve Co.
Reading Valve & Fittings Div.
Richardson-Phenix Division
Vogt Machine Co., Henry

Valves, Throttle
Homestead Valve Mfg. Co.
Lunkenheimer Co.
Nelson Valve Co.
Protected Seat Valve Co.

Valves, Trip Throttle
Mason Regulator Co.

Valves, Vacuum
Mason Regulator Co.
Protected Seat Valve Co.
Sarco Co., Inc.
Webster & Co., Warren

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Coppus Engr. & Equip. Co.
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Buffalo Forge Co.
Buffalo Steam Pump Co.
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Reliance Gauge Column Co.
Wright-Austin Co.

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American Mfg. Co.

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Wrenches, Pipe
Armstrong Mfg. Co.
Trimont Mfg. Co.

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"PERFECTLY satisfactory and no repairs." This is the statement from the engineer in charge of the Terry Turbines, installed at the Lever Bros. Co., Cambridge, Mass. This is not typical of all Terry turbine installations, for it must be recalled that Terry turbines were being manufactured over twenty years ago. There is no moving mechanism built, which will run forever with out replacing the wearing parts, and the Terry turbine is no exception to this rule. For this very reason The Terry Steam Turbine Company maintains a very complete and extensive stock of repair parts ready for immediate shipment and a force of trained men in the field for the purpose of making replacements when necessary. The fact that Lever Bros. have as yet made no repairs is significant of the fact that Terry turbines with the proper attention to lubrication and adjustment are free from operating kinks and troubles and will continue to give good service during the calculated life of their wearing parts.

Write for Bulletin No. 25-A, which contains a complete detail of these working parts and loads and stresses imposed upon them. You will then appreciate how small your replacement charges will be, should you select

T-777

THE TERRY TURBINE

Offices in Principal Cities in U.S.A. also in Important Industrial Foreign Countries

The Terry Steam Turbine Co.
Terry Sq. Hartford, Conn. U.S.A.

ALPHABETICAL INDEX TO ADVERTISEMENTS

	Page
Abendroth & Root Mfg. Co.	68
Advance Packing & Supply Co.	45
Alberger Heater Co.	59
Alberger Pump & Condenser Co.	58
Allis-Chalmers Mfg. Co.	85
American Chimney Corp.	74
American District Steam Co.	48
American Engineering Co.	10
American Manufacturing Co.	54
American Steel & Wire Co.	54
Anderson Fdry. & Machine Co.	82
Armstrong Machine Works	61
Ashton Valve Co.	46
Atlas Valve Co.	27
Automatic Furnace Co.	76
Babcock & Wilcox Co.	69
Badenhausen, Phillips	68
Badger Fire Extinguisher Co.	82
Bailey Meter Co.	Second Cover
Barrett, Haentjens & Co.	52
Betson Plastic Fire Brick Co.	72
Biddle, James G.	62
Bigelow Co.	69
Binks Spray Equipment Co.	60
Blackburn-Smith Corp.	54
Boiler Tube Co. of America	72
Brady Fdry. Co., Jas. A.	52
Bristol Co.	Fourth Cover
Brownell Co.	62
Brown Hoisting Machy. Co.	58
Buffalo Forge Co.	9
Buffalo Steam Pump Co.	56
Builders Iron Fdry.	64
Bundy Steam Trap Co.	59
Busch-Sulzer Bros.—Diesel Engine Co.	78
Caldwell Co., W. E.	78
Celite Products Co.	79
Centrifugal Fan Co.	53
Chadburn Engineering Co.	64
Chaplin-Fulton Mfg. Co.	61
Chapman Valve Mfg. Co.	30
Chase Companies	89
Chesterton Co., A. W.	45, 66
Chicago Pneumatic Tool Co.	79
Clarage Fan Co.	80
Cling-Surface Co.	56
Coatesville Boiler Works	68
Cokal Stoker Corp.	78
Combustion Engrg. Corp.	14-15
Connelly Boiler Co., D.	69
Conveyors Corp. of America	12
Cook's Sons, Adam	81
Cooper Co., C. & G.	80
Coppus Engr. & Equip. Co.	56-82
Cory & Sons, Chas.	64
Crandall Packing Co.	45
Crane Co.	52
Cresson-Morris Co.	54
Crocker-Wheeler Co.	82
Custodis Chimney Const. Co., Alphons.	74
Cyclone Grate Bar Co.	76
Dart Mfg. Co., E. M.	52
Davis Regulator Co., G. M.	58
Davis & Sons Co., J. F.	68
Davidson Co., M. T.	59
Dean Bros. Steam Pump Works	58
Dean Limited, Payne	53
Defender Automatic Regulator Co.	62
Delany & Co., P.	68
De Laval Steam Turbine Co.	83
Detrick Co., M. H.	72
Detroit Stoker Co.	75
Dexter Co., I. H.	81
Direct Separator Co.	58
Earle Gear & Machine Co.	54
Edge Moor Iron Co.	70-71
Edward Valve & Mfg. Co.	39
Electric Machinery Mfg. Co.	76
Elliott Co.	5
Ellis Co., W. E.	74
Engineer Co.	72
Engineers Directory	40
Erie City Iron Works	68
Ernst & Co.	61
Esterline-Angus Co.	64
Excello Mfg. Co.	74
Eynon-Evans Corp.	80
Fitchburg Steam Engine Co.	79
Flynn & Emrich Co.	72
Foremost Engineering Corp.	62
Foxboro Co.	64
Fulton Iron Works Co.	87
France Packing Co.	45
Garlock Packing Co.	22
Gibby Engineering Co.	74
Gifford-Wood Co.	52
Godfrey Conveyor Corp.	51
Goetze Gasket & Packing Co.	47
Goodrich Rubber Co.	53
Green Engineering Co.	18-19
Green Fire Brick Co., A. P.	76
Green Fuel Economizer Co.	53
Greene, Tweed & Co.	79, Fourth Cover
Griscom-Russell Co.	29
Guarantee Construction Co.	48
Hadfield-Penfield Steel Co.	81
Hagan Corp.	61
Harbison-Walker Refractories Co.	77
Harrisburg Fdry. & Machine Works	81
Hays Corp., Jos. W.	58
Hayward Co.	52
Heine Boiler Co.	Front Cover
Hofft Co., M. A.	77
Homestead Valve Mfg. Co.	48
Hope Engineering & Supply Co.	82
Hoppes Mfg. Co.	62
H. S. B. W.-Cochrane Corp.	36
Hunt Co., C. W.	53
Illinois Stoker Co.	24
Ingersoll-Rand Co.	25
International Filter Co.	74
Irving Iron Works Co.	49
Jefferson Union Co.	81
Jeffrey Mfg. Co.	28
Jenkins Bros.	4
Johns-Manville, Inc.	7
Jointless Fire Brick Co.	73
Keeler Co., E.	69
Keasbey & Mattison Co.	32
Kennedy Valve Mfg. Co.	47
Kerr Turbine Co.	82
Keystone Lubricating Co.	3
King Construction Co.	59
King Refractories Co.	74
Ladd Co., Geo. T.	68
Lagonda Mfg. Co.	Third Cover
Lammert & Mann Co.	78
Lea-Courtenay Co.	54
Lebanon Boiler Works	68
Liptak Fire-Brick Arch Co.	74
Littleford Bros.	74
London Steam Turbine Co.	77
Lunkenheimer Co.	16
McClave-Brooks Co.	26
McDonough Coal Saving Corp.	66
McGowan Co., John H.	59
McGraw-Hill Book Co.	55
McIntosh & Seymour Corp.	82
McLeod & Henry Co.	72
Manistee Iron Works Co.	54
Marion Mach. Foundry & Supply Co.	77
Mason Regulator Co.	50
Maxim Silencer Co.	78
Moore Steam Turbine Corp.	82
Moore & White Co.	80
Morehead Mfg. Co.	74
Morrin-Climax Boiler Co.	68
Morris Machine Works	59
Morse Chain Co.	56
Murphy Iron Works	20
National Pipe Bending Co.	46
Neemes Bros.	72
Nelson Valve Co.	8
New Bedford Valve Mfg. Co.	46
Newburgh Steam Boiler Works	68
New York Belting & Packing Co.	38
Nicholson & Co., W. H.	92
Northern Equipment Co.	13
Nugent & Co., Wm. W.	72
Ohio Body & Blower Co.	65
Ohio Grease Co.	78
Oil City Boiler Works	68
Orton & Steinbrenner Co.	54
Page Boiler Co.	69
Parkesburg Iron Co.	68
Patterson-Kelley Co.	50
Pennsylvania Pump & Compressor Co.	56
Perfection Grate & Supply Co.	76
Permutit Co.	61
Petty & Co., J. K.	68
Pittsburgh Piping & Equip. Co.	46
Pittsburgh Steel Products Co.	66
Powell Co., Wm.	46
Power Specialty Co.	66
Power Turbo-Blower Co.	79
Powers Regulator Co.	60
Pratt & Cady	50
Protected Seat Valve Co.	47
Quaker City Rubber Co.	45
Reading Steel Casting Co.	46-50
Reading Valve & Fittings Division	46
Reliance Gauge Column Co.	62
Republic Flow Meters Co.	63
Rhoads & Sons, J. E.	50
Richardson-Phenix Division, S. F. Bowser & Co.	11
Ridgway Dynamo & Engine Co.	79
Riley Stoker Co., Sanford	20
Roach Stoker Co.	72
Robertson & Sons, Jas. L.	48-64
Rogers Co., H. A.	60
Ross Heater & Mfg. Co.	56
Roto Co.	64
Sarco Company	60
Scaife & Sons Co., Wm. B.	62
Schaeffer & Budenberg Mfg. Co.	60
Schieren Co., Chas. A.	45
Schutte & Koerting Co.	47-48
Searchlight Section (See Alphabetical Index below)	41-44
Sherwood Mfg. Co.	50
Smith & Serrell	56
Smooth-On Mfg. Co.	31
Spray Engineering Co.	59
Springfield Boiler Co.	68
Squires Co., C. E.	59
Stearns Conveyor Co.	52
Steel-Flex Coupling Corp	81
Stewart Heater Co.	59
Strong, Carlisle & Hammond Co.	23
Stumpf Una-Flow Engine Co.	79
Sugar Apparatus Mfg. Co.	60
Sullivan Machinery Co.	80
Sun Co.	80
Superheater Co.	67
Taber Pump Co.	56
Taylor Instrument Co.'s	64
Templeton Mfg. Co.	61
Terry Steam Turbine Co.	91
Toledo Pipe Threading Machine Co.	57
Trimont Mfg. Co.	60
Twinvolute Pump & Mfg. Co.	58
Uehling Instrument Co.	64
Under-Feed Stoker Co. of America	77
Underwood Corp., H. B.	76
Union Iron Works	68
United Conveyor Corp.	54
United Machine & Mfg. Co.	17
Valley Iron Works	77
Vilter Mfg. Co.	79
Vogt Bros. Mfg. Co.	76
Vogt Machine Co., Henry	60
Walker & Co., Ltd., James	45
Warren Steam Pump Co.	58
Watson & McDaniel Co.	61
Webster Mfg. Co.	52
Webster & Co., Warren	61
Westinghouse Elec. & Mfg. Co.	6
Wheeler Mfg. Co., C. H.	58
Wheeler Condenser & Engr. Co.	53
Wickes Boiler Co.	69
Wing Mfg. Co., L. J.	72
Worthington Pump & Machy. Corp.	57
Wright-Austin Co.	60
Yarnall-Waring Co.	21
York Mfg. Co.	74

INDEX TO SEARCHLIGHT SECTION

	Page
Benholts, Roy	44
Briggs, Inc., Marvin	42
Davis, J. F.	44
Duquesne Electric & Mfg. Co.	43
Essex Engine & Machine Corp.	42
Harris Bros.	44
Kehoe, Robt. P.	42
MacGovern & Co.	44
McMillan, A.	44
Machinery Utilities Co.	44
Marham Engr. Co.	43
Nashville Industrial	41-42
National Business Bourse	41
O'Brien Mchy. Co.	43
Positions Vacant and Wanted	41
Power Machinery Exchange	42
Ross Power Equipment Co.	43
Wickes Mchy. Co.	44